SYSTEMS VIEW OF ENERGY EFFICIENCY IN NEW HOUSING

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by

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Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under Part V of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has a statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions.

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ABSTRACT

The report examines the constraints and barriers to the achievement of energy efficiency in new housing, and suggests methods by which such barriers may be removed. The potential roles of Government are identified that could expedite the installation of energy saving measures in new homes. These include the dissemination of quantitative information on the performance and the financial advantages of various energy saving measures, and the provision of grants that reflect the societal benefits provided by the measures. Based partly on economic analysis and partly on a survey of builders and consumers, the study concluded that the key factors in people's decisions to install energy saving measures in new homes are financial. It also concludes that those measures that provide the largest financial savings to the home owners are already being installed to a greater extent than before and, while offering relatively few additional energy saving measures on their options' lists, most builders are highly responsive to any requests made for such options by the home buyers.

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PREFACE

Canada Mortgage and Housing Corporation is the housing agency of the Federal government. The mandate for the Corporation's activities is set out in the National Housing Act. In terms of energy conservation, two aspects of the mandate have to be balanced; keeping housing affordable to the consumer, and support of federal energy initiatives. These two objectives are sometimes in conflict.

This study arose from observations that, outside of specific energy conservation programs and demonstrations, there was little noticeable market movement toward energy efficient housing. The study aimed at looking at energy conservation from a wider perspective than that of simple energy savings - the "system" within which a decision is made to buy a new home. The "system" included implicit and explicit financial decisions (economic factors), options available at time of purchase (supply factors), concerns with the effects of energy conservation (performance factors), and third party influences (institutional factors). The expectation was that this investigation would lead to further clarity in reconciling energy conservation expenditures with affordability issues, as well as pinpointing the major barriers to widespread adoption of energy efficiency in new housing.

The funding for this project was provided by the Panel for Energy Research and Development and was administered under Part V of the National Housing Act.

The report is published in two volumes; the main report comprises the first part, and supporting materials (Appendices A-G) the second.

ACKNOWLEDGMENTS

We gratefully acknowledge the assistance and advice received from builders and other representatives of the housing industry who readily responded to our survey and inquiries. We are also thankful for the cooperation of the consumers who participated in the interview survey, and provided much of the information used in the study.

SYSTEMS VIEW OF ENERGY EFFICIENCY IN NEW HOUSING

EXECUTIVE SUMMARY

Energy efficiency in housing is an important component of Canada's overall objective of achieving energy self-sufficiency. The purpose of this study was to identify any constraints or barriers to the achievement of energy efficiency in the new housing market and to investigate methods by which such barriers may be removed. In particular, the study was to identify the role that Government can assume to expedite the installation of energy saving measures. The study focused on low rise tract development in urban areas.

A survey of builders and new home buyers indicated that most consumers would not find an energy saving measure attractive if their expected energy cost savings during the next five to ten years did not justify the initial extra costs. The survey also indicated a marked improvement in building practices. Consequently, houses built today have generally better insulation and are being built to higher standards of airtightness than houses built quite recently. This, coupled with the consumers' requirements for financial justification, limits the range of energy saving measures that would appeal to the consumers and are not already provided as standard.

The range is particularly limited in the urban areas of B.C., Alberta and Saskatchewan, where mild climate or low energy prices tend to reduce the potential savings in energy costs.

The greatest opportunity for increased energy savings in new housing is presented by improved efficiency and super efficient furnaces. These devices may be installed in homes with standard insulation or may be combined with improved insulation levels. Houses with heat pumps also save energy but only when compared with homes that have equivalent air conditioners. Measures requiring minimal investment, such as passive solar layouts (large windows facing south) and time controlled thermostats, were found to be extremely effective. Considering their financial advantages, it was surprising that they have not yet penetrated the market more.

Home owners generally find the energy savings achieved through high levels of airtightness too small to justify the initial costs. The savings are small because airtightness cannot be increased much above the levels already achieved in new houses, for reasons of health, safety and the prevention of potential moisture damage. Although it is possible to recover a significant portion of the heat from the exhaust air through heat exchangers, for the time being these devices are still overly expensive in relation to the costs of the energy they save.

Another barrier to the penetration of high levels of airtightness, with or without heat recovery sytsems, is the inadequate knowledge about the minimum air change rates that are required under various circumstances in the home.

More research and the development of guidelines would help in optimizing the design and the construction of homes with the most appropriate airtightness and the design of the most appropriate heat recovery systems.

Some lack of field experience with heat pumps, particularly with maintenance costs and useful life, appears to be a barrier to greater market penetration. Appropriate surveys for obtaining this information and the dissemination of the information to the public would enhance the understanding of the heat pumps' net advantages by the consumers, the builders and the contractors.

Builders of new homes are generally ready and willing to install any energy saving measures the consumers require. Although many builders do not take the initiative to offer such measures as options, this rarely prevents the installation of a measure requested by a customer, as the majority of houses are actually built after they had been sold.

The potential role of Government in enhancing the penetration of energy saving measures in new housing has been identified in three areas:

- dissemination of information
- research and development
- financial assistance.

Information on those "facts and figures" that do not require further technical research or surveys can be disseminated to the public without much delay. This information would show the financial advantages of energy saving measures installed in homes of various types and sizes, under a range of external economic conditions. It would also provide data on the average energy costs of typical homes so that consumers who have installed the measures can evaluate their savings and demonstrate them to others.

Accelerated research in the area of airtightness, the provision of incentives for the development and low-cost mass production of heat recovery systems, and the collection of more information on heat pumps are other examples of potential Government initiatives.

In addition to the financial benefits accruing to the home buyers themselves, energy savings generate additional benefits to society at large in terms of security of energy supply and balance of foreign trade. Government is therefore justified in sharing some of these social benefits with the providers and buyers of energy saving measures. Support to research and development is one method of sharing the benefits. Another effective method is the provision of grants to the consumers. A broad evaluation indicated that long term social benefits would justify grants covering as much as 30% of the increase in the consumers' capital costs resulting from the installation of "optional" energy saving measures.

SYSTEMS VIEW OF ENERGY EFFICIENCY IN NEW HOUSING

I. PURPOSE AND FOCUS OF THE STUDY

Energy saving in housing is an important component of Canada's national objective of achieving energy self-sufficiency before the end of this century. The purpose of this study was to show how energy-efficiency can be improved in new housing. The methods of achieving this goal are somewhat different from those applicable to existing homes (addressed in a separate study).

Specifically, this report:

- defines the sets of energy conserving measures (features) that were investigated in the study;
- identifies and describes relevant factors which potentially impact on the achievement of energy efficient new housing;
- identifies and describes relevant interactions among the measures and factors and determines the importance of the interactions;
- within the framework of the feasible options, identifies and describes barriers or constraints that presently stand in the way of implementing energy efficiency and investigates how these barriers may be removed or resolved;

- offers recommendations regarding the role that government can assume to expedite the resolution or removal of the barriers.

The focus of the study was defined as follows:

- Low-rise urban dwellings in tract developments. These make up the greatest proportion of the number of dwellings and, therefore, are most influenced by the barriers resulting from public opinion and consumer behaviour. For that reason they have the greatest potential for improvements in energy savings that can be achieved through appropriate public policy.

- Identifying the barriers to the penetration of energy saving measures and the means of removing the barriers, without attempting to forecast the actual amounts of energy savings that could be achieved in Canada by those means.

- Current market conditions as the parameters for the perspectives of consumers and builders.

II. STUDY APPROACH

As noted in the preceding Chapter, the major thrust of the study was to identify major barriers that may prevent or delay the implementation of energy saving measures in new housing in Canada. The identification of such barriers was to be followed by the development of recommendations for the most effective ways in which the barriers or constraints can be overcome.

The study was carried out using the following approach:

1. The energy saving measures to be evaluated in the study were identified.

2. These measures and their combinations were evaluated in economic terms, considering those factors that determine the financial and economic advantages or disadvantages of the measures.

3. Additional factors were identified of a largely non-economic nature, which might influence the suppliers and buyers of new homes in their decisions to install energy saving measures.

4. Those measures (and their combinations) that provide economic advantages to homeowners were further evaluated in terms of the identified non-economic factors, based on a survey of builders and buyers of new homes.

5. From these evaluations several barriers were determined that stand in the way of a wider acceptance of effective energy saving measures.

6. Methods were defined for removing or resolving these barriers. Those energy saving measures that would not appear to be financially attractive to the buyers of new homes, but would produce net long term social benefits, were further examined from the public perspective. Methods were suggested that Government might use to make these measures financially attractive to the homeowners.

III. THE ENERGY SAVING MEASURES

The economic and technical feasibility of various energy saving measures applicable to residential buildings has been studied for some time by Government, industry and the academic community. This work, initiated by the rapid rise in energy prices since 1973, has been characterized in its early stages by an all-out effort to save non-renewable energy at practically any price. As time progressed and the feasibility of alternate indigenous energy sources became apparent in Canada and elsewhere, several methods of energy savings were found to be too costly in terms of expected future returns on the initial investment, or impractical for other reasons. Examples of such methods were earth sheltered homes or thermal storage.

Upon consideration of the state of the art in the development of energy saving measures, the following categories of measures were selected for analysis in this study:

(i) Measures that do not require significant capital investment. These include such measures as time-controlled thermostats that automatically lower the house temperature during the night or during other pre-set periods, or passive solar design features that maximize the useful exposure of the house to solar heat through large windows facing south.

(ii) Improved heating devices. These devices save energy by increasing the ratio of the energy delivered for heating the house to the energy contained in the fuel.

(iii) Insulating the envelope of the house. This category of measures includes the installation of extra

insulation in the ceiling, in the walls and in the floors and extra glazing of the windows, with the objective of reducing the heat loss of the house.

(iv) Reducing the heat lost through air change. This category of measures implies improved airtightness in the construction of homes combined with the appropriate control of air flow, to ensure a rate of air change that is optimal from the point of view of health and safety. A further development of these measures provides means to recover most of the heat contained in the outflowing air and to recycle it into the house.

Within each of these categories, the following energy saving measures were identified:

Low investment measures:	Time-controlled thermostats
	Passive solar layouts
Efficient heating devices:	Improved efficiency gas and oil furnaces
	Condensing gas furnaces
	Super efficient oil furnaces
	Heat pumps
Insulation:	"Level 1" insulation (1)
	"Level 2" insulation (2)
	"Level 3" insulation (3)

(1) R = 6.2 $^{o}m^{2}$/watt in roof, 3.1 in walls, 1.7 in foundation (1.8 m below grade), triple glazed windows.
(2) R = 7.6 $^{o}m^{2}$/watt in roof, 3.4 in walls, 3.1 in foundation (1.8 m below grade), triple glazed windows.
(3) R = 10.6 $^{o}m^{2}$/watt in roof, 6.1 in walls, 5.2 in foundation (1.8 m below grade), quadruple glazed windows.
Base Case: R = 5.0 $^{o}m^{2}$/watt in roof, 2.5 in walls, 1.7 in foundation (0.6 m below grade), double glazed windows.

Improved air tightness with Controlled outward air flow:	Outward air flow through exhaust fan
	Outward air flow through heat exchanger

These measures and their combinations are described in detail in Appendix A and will be discussed in more detail in Chapter IV. While none of the measures represent future technology, most of the mechanical devices listed above have not been on the market for more than a few years.

Energy savings related to hot water heating or lighting were also examined in the study, but were not analyzed in detail. The absolute annual savings that could be achieved within these energy uses are too small to be seriously considered by a home buyer at the time of making a very large investment in a house.

IV. STUDY RESULTS

1. ECONOMIC EVALUATIONS

The home buyers' principal reason for having energy saving measures installed in their new homes is to save money in the medium and long term. If the expected savings in future energy bills appear to be attractive to the home buyers in relation to the extra investment they have to make, and if there are no negative non-economic factors, the chances are good that buyers of new homes will install energy saving measures (or buy a house with such measures already installed). However, if the energy cost savings derived from the measures are not perceived by the home buyers as being sufficiently attractive in financial terms, they would generally not make an investment for the purpose of future energy savings.

Although there may be some people who would install visible energy saving features as a form of social expression, it is believed that these instances are rather exceptional.

The criteria by which a typical buyer of a new home would define "financial advantage" are discussed in considerable detail in Appendix B. As shown in the Appendix, the judgement of home buyers would generally range between the two extremes described below.

Shortest Term View:

A home buyer who would finance the additional investment represented by the energy saving measures from his own cash funds (either because he finances his entire investment from the sale of another house or because he has reached his borrowing limits) might be willing to invest in the energy saving measure if its capital cost

was not greater than 5 times the energy cost saved in the first year. This means that, ignoring interest on the one hand and energy price increases on the other, the maximum acceptable payback period considered by the buyer would be 5 years.

A new home buyer who obtains a mortgage under the regulations of the National Housing Act could obtain additional funds if his expected annual expenses on energy could be reduced. If the limit on the home buyer's annual payments of principal, interest, taxes and energy (PITE) was 32 percent of his annual income, a saving in projected energy costs can be exchanged for an increase in the principal/interest portion of this annual payment limit. Assuming a mortgage rate of 12.5 percent and repayments of principal based on 25 years, for every $100 expected to be saved in energy the home buyer can borrow an extra $750. An energy saving device costing five times the achievable energy cost savings in the first year would thus be attractive to a home buyer who has limited borrowing capability and a short time horizon. However, a device costing more than five times the first year's saving would be regarded as rather marginal.

Longest Term View:

A buyer with a very long term horizon would consider payback over the same time period as the planned duration of his mortgage, such as 25 years. Such a buyer would implicitly or explicitly consider energy prices rising faster than inflation but, on the other hand, would also consider the future payments of interest and principle related to the energy saving investment. The

> home buyer would make the investment in the energy saving measure if, in his view, the projected savings in fuel bills during future years will equal or exceed the increased annual mortgage payments resulting from the extra investment. It is shown in Appendix B that a long term analysis of financial flows (assuming a real(1) mortgage rate of 5% and a real(1) annual energy price escalation rate of 2%) justifies a maximum investment of 17.5 times the energy costs saved in the first year.

As noted, the yardsticks that most home buyers would use in deciding whether to invest additional funds in an energy saving measure would be between these two extremes. One of the most useful functions that Government may perform in encouraging the greatest number of home buyers to move toward the "longest term view" would be the publication of easy-to-understand graphs and tables of projected costs and savings. These graphs and tables would reflect the results of the appropriate long term financial analyis and would make these results available to everyone, without having to address the details of the calculations.

An important consideration impacting on the decisions of home buyers is the expected resale value of the house. A substantial percentage of new home buyers responding to the survey carried out in this study did not believe that energy saving measures would increase the value of their homes.

This finding indicates that a useful role of Government could be the annual publication of average energy expenses for houses of specific sizes and types, by city, so that homeowners and buyers of houses in

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(1) "Real" interest and price escalation rates are net of the rates of general inflation (as defined by the increase in the Consumer Price Index).

EXHIBIT 1

CASES STUDIED

	HALIFAX	MONTREAL	OTTAWA	EDMONTON	VANCOUVER
BUNGALOW ($100\ m^2$)			GAS (59.9)		
2-STOREY DETACHED ($125\ m^2$)	OIL (51.5)	ELECTRICITY (58.1)	GAS ELECTRICITY (58.1)	GAS (70.0)	GAS (31.6)
SEMI-DETACHED ($130\ m^2$)			GAS (53.1)		
ROW/TOWNHOUSE ($102\ m^2$)	OIL (27.5)	ELECTRICITY (31.9)	GAS ELECTRICITY (32.2)	GAS (39.1)	GAS (15.6)
LOW-RISE APARTMENT ($84\ m^2$)			GAS (26.6)		

GJ/YEAR IN "BASE" CASE

the resale market could make meaningful comparisons. With such publications a seller of an energy-efficient house could demonstrate to would-be buyers how much lower the energy expenses of the house have been than the average expenses for equivalent homes in the city, and could use this information as a selling tool.

After having defined the range of the consumers' financial evaluation criteria, each identified energy saving measure was subjected to a thorough economic evaluation to determine whether it was within that range. This analysis is described in Appendix C. It required:

- the development of engineering specifications for the energy saving measures,

- estimating the costs of both the investment and the expected energy savings,

- combining the various measures so as to achieve maximum savings for a given investment, and

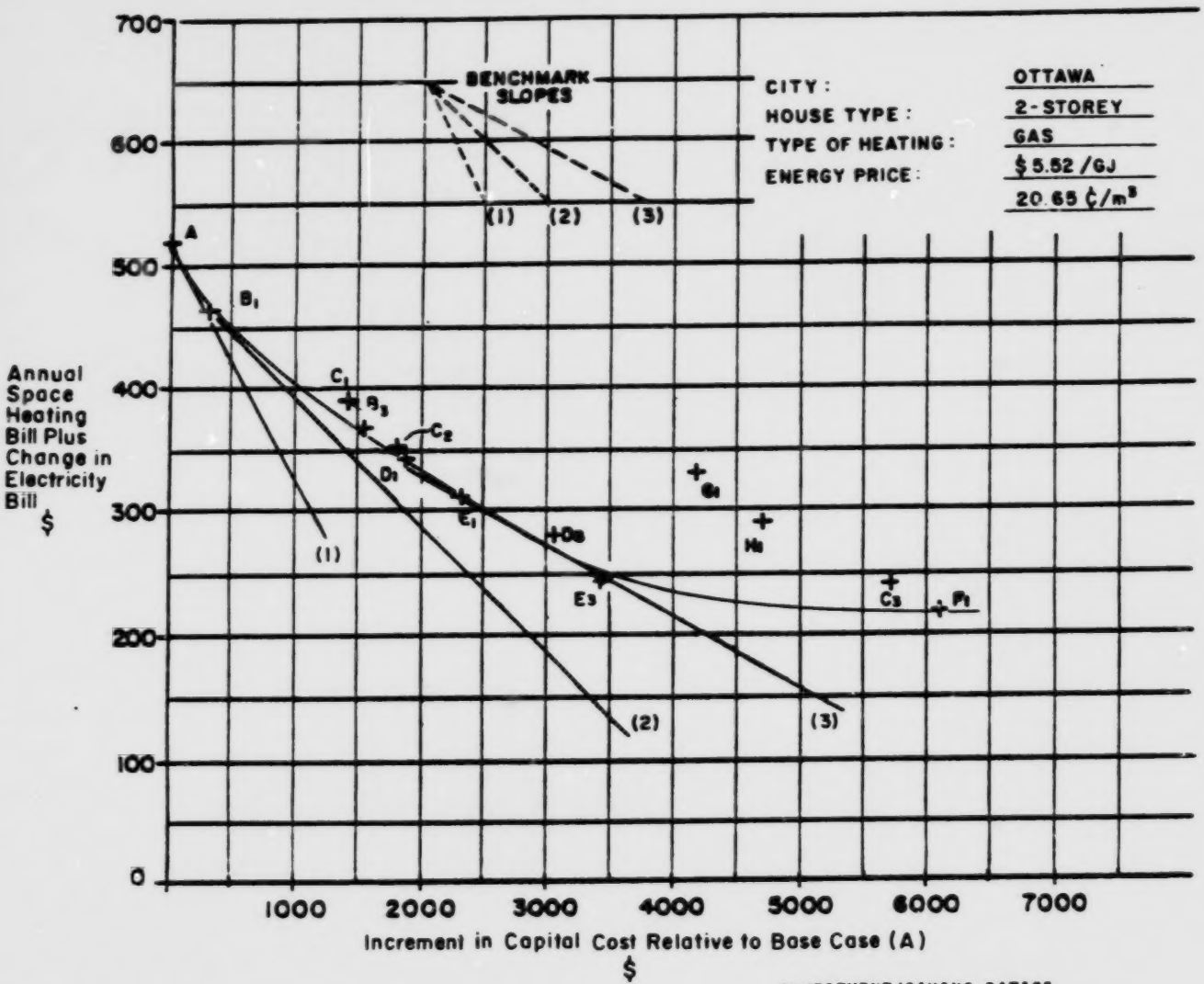
- expressing the annual savings in terms of the initial investment and comparing the results with the consumers' financial criteria.

The CMHC-2 Model was used as the data source and calculator of energy savings for five different house types and five typical urban areas in Canada. Exhibit 1, on Page 12, shows the cases for which calculations were performed.

For each urban area the regionally most popular fuel type was chosen. For two house types in Ottawa the computations were carried out for both gas and electric heating since the costs of the two energy types are not far apart in that city. As indicated by Exhibit 1, the houses chosen for analysis were of relatively modest size.

EXHIBIT 2

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

It should be noted that the house types and sizes, as well as the cities selected for the analysis, were not intended to be representative of all market segments or all geographic areas in Canada. They are representative, however, of a sufficiently large portion of the new housing market to indicate the nature and extent of the major barriers to the implementation of effective energy saving measures.

The various energy saving measures listed in Chapter III were examined individually as well as in logical combinations. The most economical combinations were determined through the preliminary testing of a larger number of alternatives and those combinations that produced significantly smaller energy savings than some other combinations for the same or higher initial capital investment were eliminated.

Exhibit 2, on Page 14, and Exhibit 3, on Page 18, are examples of the results obtained from the analysis. On the horizontal axis the graphs show the initial investment in the energy saving measures, or groups of measures, listed below the graphs. The vertical axis shows the amount paid for space heating by the owner of the new house in the first year after the purchase, including the fuel bill and any incremental maintenance costs that may be incurred as compared with the "base case". The "base case" was specified as representing an averge house that incorporates today's standard practices in building and equipment. Its specifications regarding insulation, airtightness, furnace types, etc. are described in Appendix A.

It can be seen that with increasing levels of investment the annual energy bill decreases. The graphs clearly indicate, however, that the relative gains in terms of savings become smaller with increasing levels of investment.

Evidently, the lower the position of a point on the graph, the lower is the annual energy bill and the greater is the annual saving for a given

investment. Exhibit 2 shows an envelope curve that can be drawn through the points of the graph in such a manner that no point is significantly below the curve. Obviously, therefore, the envelope curve represents the maximum annual energy cost saving that can be achieved for a given investment.

Whether a home buyer will consider the investment in an energy saving measure worthwhile, depends on the amount of the projected annual savings in relation to the investment. That relation is represented by a slope, drawn from some reference point to the point under evaluation. The steeper the slope, the larger is the saving in relation to the capital cost.

The "benchmark slopes" shown on the graphs mark the likely range of financial criteria applied by various home buyers. A home buyer is likely to decide against investing in an energy saving measure if the annual saving is not large enough in relation to the investment, i.e., if the slope is not steep enough in the eyes of the buyer.

The slopes take into consideration the expected increase in energy rates, as explained in Appendix B. The steepest slope (1) represents the shortest term view and the least steep slope (3) represents the longest term view described earlier. Slope (2) represents a "middle of the road" view: an investment equal to 10 times the energy cost saved in the first year.

Unless subsidized by Government, the installation of a measure that falls outside Slope (3) would be against a home buyer's financial interest, even if he accepted the longest term view and received professional advice that applied that view to an appropriate financial analysis. According to the findings of this study, however, most people wold be unlikely to consider a measure that falls outside Slope (2), i.e., one that costs more than 10 times the first year's savings it

produces. As noted and discussed later, one of the most useful roles of Government could be the extension of peoples' horizon from the one represented by Slope (2) to that represented by Slope (3), through appropriate information pamphlets and easy-to-understand financial tables.

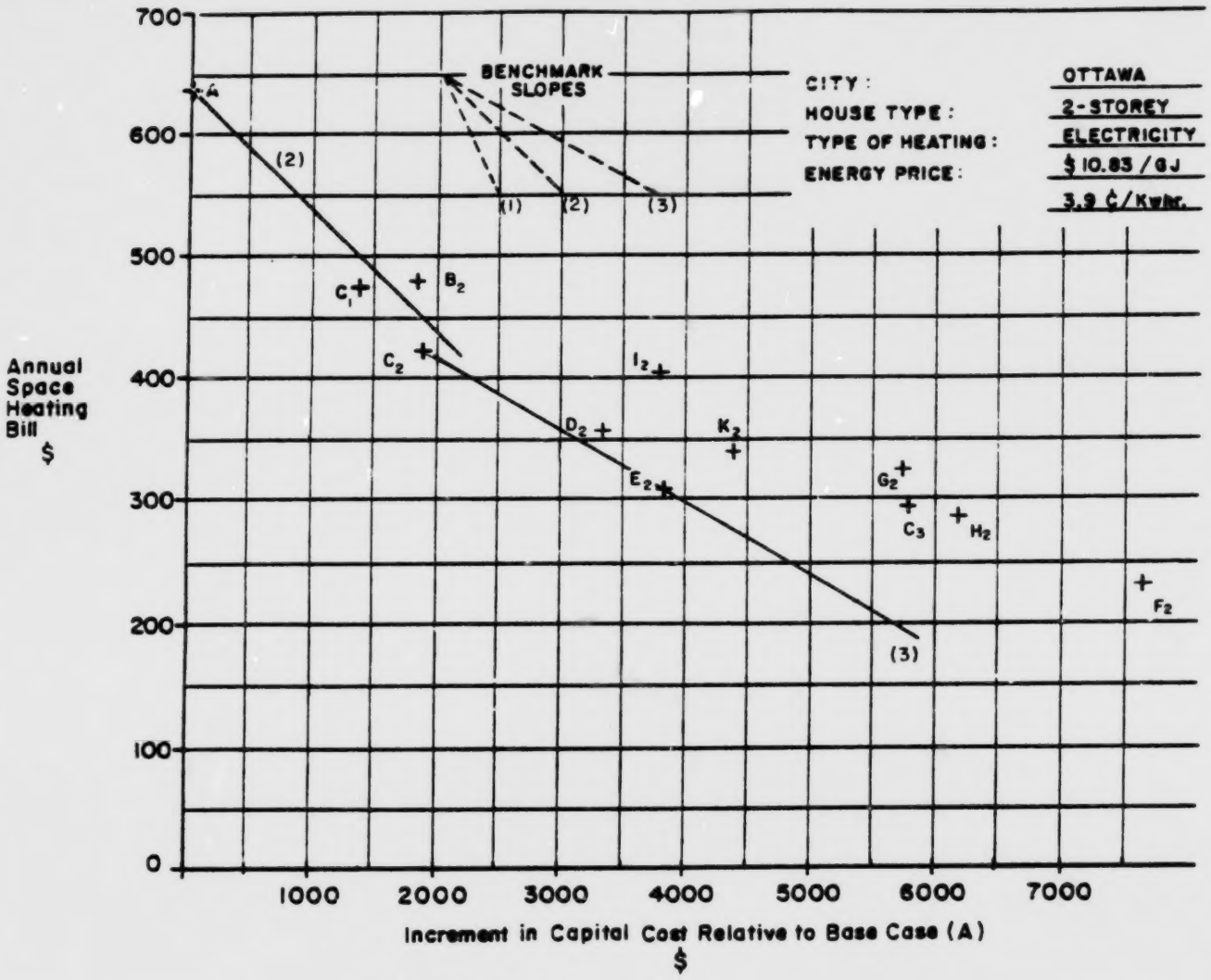
Without subsidies the government could not recommend the adoption of measures outside Slope (3), since that would mean a likely financial loss to the home buyer compared to other investment opportunities. As discussed later, however, measures outside Slope (3) could still be beneficial from the public perspective and can be made attractive to the private home buyer through appropriate subsidy policies.

When comparing two options, the option with the higher capital investment is not desirable financially to the consumer unless the additional projected annual energy cost savings are greater than the minimum acceptable savings indicated by the "benchmark slopes". In other words, if the slope between the points representing the two compared options is flatter than the "benchmark slope" the incremental saving produced by the more costly investment option is insufficient to justify the excess capital that would have to be invested in order to achieve the extra saving.

The graphical evaluation process can be clearly followed in the example shown in Exhibits 2 and 3. These Exhibits relate to a 2-storey detached house, with gas and electric heating respectively in Ottawa. To explain the graphs, consider, for example, the point of view of a "middle of the road" home buyer who expects to save at least one tenth of his investment in the first year. This view is represented by Slope (2). Among the options shown in Exhibit 2 (on Page 14) compare, for example, Option B_1 (Improved Furnace) with Option E_3 ("Level 2" Insulation plus Condensing Gas Furnace). The slope between the two points is less steep than the "middle of the road" benchmark slope (2) and,

EXHIBIT 3

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B2 HEAT PUMP *

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D2 INSULATION "1" + HEAT PUMP *
E2 INSULATION "2" + HEAT PUMP *
I2 INSULATION "1" + HEAT PUMP *

G2 SAME AS D2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H2 SAME AS E2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

I2 INSULATION "1" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
K2 INSULATION "2" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

* Excess capital cost over equivalent air conditioner

therefore, the difference in energy cost savings between the two options is not enough to compensate people with 10-year horizons for the difference in investment costs. However, for home buyers with 25-year horizons Option E_3 would be attractive when compared with Option B_1, since these two points are both on Slope (3).

The only option that home buyers with a 5-year horizon would find attractive would be Option B_1 in comparison with the Base Case (A) since B_1 is the only point below Slope (1) or approximately on it.

Considering Benchmark Slope (3), which represents the 25-year horizon, all the options along the envelope curve are economical, down to Option E_3 ("Level 2" Insulation plus Condensing Gas Furnace). In a strict sense, Option D_3 ("Level 1" Insulation plus Condensing Gas Furnace) is not economical when compared with Option E_1 since the slope between the two points is somewhat less steep than Slope (3). However, D_3 is not much above Slope (3) drawn from point E_1. Thus, when the margins of error in the data are recognized, D_3 may not necessarily be ruled out by a home buyer, even though his first-year energy cost savings may appear to be somewhat below the desired minimum (1/17.5 of the initial investment).

Exhibit 2 indicates that Option E_3 ("Level 2" Insulation plus Condensing Gas Furnace) presently represents the ultimate opportunity for energy savings in a modest ($125m^2$) two-storey house in Ottawa for the most savings-minded home buyers, represented by Slope (3). This option costs about $3,500 to install and saves approximately $275 in the first year after installation: about 55% of the energy bill of Option A (the "base case" option with no energy saving measures).

In general terms, measures represented by points that are well above the envelope curve or to the right of the part of the curve that runs parallel (tangentially) to the least steep benchmark slope cannot be justified financially by the buyers of new homes without government subsidy.

Exhibit 3, on Page 18, shows the options for an electrically heated home in Ottawa. It should be noted that the evaluation of heat pumps for such homes was carried out from the point of view of those home buyers who would install air conditioning in their homes if they did not buy a heat pump. For that reason only the incremental costs of heat pumps were considered.

The most interesting finding from Exhibit 3 is the uneconomic position of Option B_2 (Heat Pump alone) vis a vis Option C_2 ("Level 2" Insulation), since the two options represent approximately identical capital investments but C_2 provides significantly greater savings in annual energy costs. However, Options D_2 and E_2 (Heat Pump combined with extra insulation) are attractive vis a vis C_2 according to the long time horizon represented by Slope (3).

The process described above was repeated for all cases studied and all options within each case. The results of the analysis are described in Appendix C. It should be emphasized that the analysis was carried out for a limited sample of typical homes which are, nevertheless, representative of a large proportion of new construction. The conclusions derived from the analysis may not be applicable to all houses, especially not to larger ones. In large houses heat losses (and therefore potential savings) are substantially greater than shown in this report but the capital costs of the equipment that can reduce these losses may be only marginally higher. Furthermore, the costs of some types of equipment may drop significantly in the future as the market for such equipment widens. The conclusions, therefore, relate to present factors that affect a large percentage of new home buyers today, but not necessarily all new home buyers at all times.

The conclusions, as derived from duplicating a home buyer's financial considerations under present (1983) prices, are summarized below.

- In Vancouver and Edmonton, the only energy saving measure that would be found financially justifiable by the most conservation-minded new home buyer is the improved furnace. Even that measure may not be justifiable for townhouses and apartments. Broad calculations indicate that the same conclusion might be valid for such other Western cities as Calgary, Saskatoon, Regina.

- In Ottawa, Montreal and Halifax, only the following measures would be found attractive by the most conservation-minded new home buyer:

    - "Level 1" or "Level 2" insulation
    - Improved Furnace in itself or combined with "Level 1" or "Level 2" insulation
    - Heat Pump[1] combined with "Level 1" or "Level 2" insulation
    - For 2-storey houses and bungalows only: Super Efficient Furnace in itself, or combined with "Level 1" or "Level 2" insulation.

- Such measures as "Level 3" insulation, in itself or in any combination, and air-to-air heat exchangers would not be found attractive by new home buyers at today's prices.

- Airtightness levels beyond the "base case", with only an exhaust fan, didn't make the preliminary list of potentially attractive measures. As explained later, a house needs the amount of ventilation assumed in the "base case" most of the time. The proportion of time during which the air change rate could be reduced below the "base case" rate through extra airtightness, without jeopardizing the structural integrity of the house, is insufficient to justify the extra costs of such airtightness.

The main reason why relatively fewer measures were found financially attractive to new home buyers than originally expected was the finding

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(1) Provided that the home buyer would install an air conditioner if he did not buy a heat pump.

that most new houses are already insulated to higher standards and have better airtightness than before. This means that new houses corresponding to the "base cases" of the analysis are already more energy efficient than most older houses. The "base cases" correspond to current construction practices, which are superior to the practices included in the 1978 "Measures".

As noted, the conclusions reached with regards to new home buyers who consider installing heat pumps were based on the assumption that these buyers would want air conditioning in the summer. Since heat pumps serve as air conditioners during warm weather, the investment in air conditioning systems is saved for those who install heat pumps. The investment costs of heat pumps used in the evaluation were the net incremental costs of heat pumps over equivalent air conditioners. For people who do not want air conditioning, the full price of the heat pump must be considered which makes this device financially unattractive when only energy savings are considered.

2. IDENTIFICATION OF NON-ECONOMIC FACTORS

There are many non-economic factors that can be expected to influence the decisions of new home buyers regarding investment in energy saving measures. The factors identified at the outset are described in detail in Appendix D. They were somewhat modified during the study and some were omitted. The factors finally selected are listed below.

A. Supply Factors

1. Potential lack of builder or product designer know-how.
2. Reputation of the product or its supplier with the builders.
3. Potential inexperience of the trades.
4. Lags in supply of homes with energy saving measures due to delayed market recognition.
5. Builders' marketing methods and the extent to which energy saving measures are used by builders as selling tools.

EXHIBIT 4

THE FACTOR/MEASURE MATRIX

-1, -2 } FACTOR HAS NEGATIVE IMPACT ON PENETRATION OF MEASURE

+1, +2 } FACTOR HAS POSITIVE IMPACT ON PENETRATION OF MEASURE

FACTORS \ MEASURES	INSULATION	IMPROVED FURNACE (GAS)	CONDENSING GAS FURNACE	IMPROVED FURNACE (OIL)	SUPER EFFICIENT FURNACE (OIL)	HEAT PUMP, ELECTRIC OR GAS BACKUP	AIRTIGHT., NO EXHAUST	AIRTIGHT., + EXHAUST	AIRTIGHT., + HEAT EXCHANGER	NIGHT SETBACK THERMOSTAT	PASSIVE SOLAR
LACK OF BUILDER & DESIGNER KNOW-HOW						-1		-2	-2		
PRODUCT'S REPUTATION WITH BUILDERS									-2		
INEXPERIENCE OF TRADES						-1	-1	-1	-1		
LAGS IN SUPPLY OF HOMES											
USED OR NOT AS SALE TOOL	+1	+1	-1		-1	-1	-1	-1	-1		
PERCEIVED HEALTH HAZARDS	-1		-1		-1		-2				
DAMAGE TO STRUCTURE & CONTENTS							-1				-1
COMFORT							+1			+1	
SUMMER EFFECTS	+1					+2					-1
AESTHETICS						-1					-1
SOCIAL IMAGE						+1					+1
REPUTATION WITH CONSUMERS						-1					
PROPERTY TAXES						-1					
BUILDING CODES											
INFORMATION TO PUBLIC	+2		-1		-1	-2	-2	-2		+1	+1
FUTURE ENERGY PRICES	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
PRICING BY UTILITIES						-1			+1		
UTILITY/REGULTORY POLICY	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

B. Performance Factors

6. Perceived health hazards.
7. Potential damage to the structure and contents of the house.
8. Interior comfort.
9. Summer effects.
10. Aesthetics.
11. Social image.
12. Reputation of the measure with the consumer.

C. Institutional Factors

13. Property taxes.
14. Building codes and standards.
15. Availability of information to the public.
16. Expectations regarding future energy prices.
17. Incentive or disincentive pricing by utilities.
18. Utility/regulatory policies to minimize rates and increase sales.

The impact of these factors on the adoption of the various energy saving measures was investigated through a survey of builders and a survey of consumers. The surveys were conducted in late 1982 and produced complete responses from 22 builders and 88 consumers.

The results of the surveys are reported in Appendix E. They were combined with information gathered from the literature and the study team's own experience.

The findings of the research are summarized in Exhibit 4, on Page 23. This table indicates the factors that have an impact on each of the energy saving measures addressed by the study. A blank in the table means no significant impact, a negative sign means a potential negative

impact (with minus 2 meaning a stronger negative impact than minus 1) and a plus sign means a potential positive impact. An evaluation of the non-economic factors is presented in Appendix F and is summarized as part of the next Section.

3. FULL EVALUATION OF THE ENERGY SAVING MEASURES

The findings on the financial attractiveness of the various energy saving measures made it possible to evaluate the responses given by the consumers and the builders to our survey questionnaires in an objective manner. Objections to measures that were found financially unattractive by our own analysis were classified as "justified" and not considered to be barriers that could be removed by appropriate action. The evaluation of each measure detailed in the Appendices, is summarized below.

Exhibit 5, on Page 26, summarizes the availability and the consumer appeal of the measures as indicated by the survey. "Availability" is defined as the sum of those cases in which a measure had actually been installed and those in which it had been offered by the builder but refused by the buyer. "Consumer Appeal" is defined as the sum of those cases in which a measure had actually been installed and those in which a buyer might have opted for a measure but did not think of it, since it was not offered by the builder.

Distinction was made in the evaluation between Western Canada (B.C., Alberta and Saskatchewan) and Central/Eastern Canada. In the Western cities that were surveyed, the incentives for energy saving measures were lower than in the East because:

- on the Pacific Coast the climate is mild
- in Alberta and Saskatchewan urban areas, natural gas is very cheap.

EXHIBIT 5

SUMMARY OF SURVEY RESULTS

	INSULATION	AIR TIGHTNESS	IMPROVED FURNACE*	HEAT PUMP**
	%	%	%	%
HALIFAX, MONTREAL, OTTAWA, TORONTO				
Measure Offered:				
(a) Actually installed:	50	29	31	16
(b) Refused:	5	0	10	10
AVAILABILITY:	55	29	41	26
Measure Not Offered:				
(c) Potential buyer:	19	15	6	16
(d) No buyer interest:	26	56	53	58
CONSUMER APPEAL (a + c):	69	44	37	32
CALGARY AND VANCOUVER				
Measure Offered:				
(a) Actually installed:	12***	27	46	0***
(b) Refused:	11***	0***	8***	8
AVAILABILITY:	23	27	54	8
Measure Not Offered:				
(c) Potential buyer:	38	19	8***	8***
(d) No buyer interest:	40	54	38***	84
CONSUMER APPEAL (a + c):	50	46	54	8

*: In Montreal: Heat pump **: Excluding Montreal ***: Very small sample

For that reason the relatively low incidence of energy saving measures in these areas can, in most cases, be explained by financial factors and can not be attributed to any of the non-economic factors investigated in this Study.

Extra Insulation

Extra insulation was found to be economically advantageous in Central and Eastern Canada. Our survey showed that in Central and Eastern Canada, 50 percent of the respondents have actually bought a house with "Level 1" insulation or better. Another 5 percent were offered the option of higher than standard insulation by the builder, but did not take it. Thus, in 55 percent of the cases, higher insulation levels were available from the builder.

Regarding the consumers' perspective, 19 percent said that they would have opted for the higher levels of insulation had they been offered by the builder. Thus, the total percentage of those homebuyers who actually had higher levels of insulation or would have opted for them was 69 percent; the remaining 31 percent either refused that option or would have refused it if it had been offered.

As shown in Exhibit 5, the percentages in Western Canada were somewhat different. Only 12 percent of the new homes were estimated to have higher than basic insulation levels (judged from a very small sample) and fewer builders offered it as an option than in the East. However, about 37 percent of the respondents said that they would have opted for a higher insulation level had it been offered by the builder while 50 percent either refused it or would not have opted for it.

Although responses to a hypothetical question are not very reliable, (since they were made without the knowledge of many relevant details, such as price) the relatively high number of positive consumer responses in Western Canada indicates that many people either over-esti-

mate the financial advantages of insulation when compared with the results of our objective analysis or do not believe in the stability of present low gas prices.

Many respondents were surprisingly familiar with the specifications of insulation. Only one person in ten said that he/she didn't know much about it or didn't think of it when looking for a house.

Airtightness

One of the conclusions of the study was that the issues surrounding airtight construction appear to need more research. There is a need to investigate the impacts of reduced air change rates on the structural integrity of the house and on the health and comfort of its occupants. In view of the uncertainties that exist in these areas it is not surprising that the issues related to airtightness are not adequately understood by the public and by the designers and builders of homes. What is required is a clarification of the requirements and the development of guidelines regarding:

- the relations between air change rates and pressure distributions, as affected by such factors as the airtightness of construction and the heating and ventilation system

- the minimum air change rates required under various levels of domestic activity.

A certain air change rate is necessary to prevent damaging condensation, to ensure the appropriate quality of the air and to minimize the hazards created by accidental buildups of unwanted gases. In a house without special ventilation or heat recovery devices the required air-changes are primarily provided by infiltration (leakage) in the inward

direction and leakage complemented, if necessary, by exhaust fans in the outward direction. Since ventilation requirements vary with the level and nature of activities in the house, fans must be operated at a frequency commensurate with these activities and must either be controlled by a humidistat or manually. Periodic opening of windows or manual operation of the fans is, of course, also a method of ensuring air change, but the effectiveness of that measure depends a great deal on the habits of the occupants. This dependence implies certain risks concerning the consequences of stale air and potential damage caused by air flows through unwanted paths.

The general opinion in the engineering community is that most houses built today have levels of airtightness that allow just enough air flow through natural leakage when the need for air changes is maximum, i.e., during the most "active" hours of the day. The same amount of leakage is, however, unnecessary during hours of low activity. During those hours the air changes do not have to meet more than the minimum requirements and, therefore, greater airtightness and reduced air flows would be beneficial.

Calculations show, however, that even if the proportion of time during which reduced air flows could be tolerated was significant, the resulting energy savings would be insufficient to justify the extra costs of tighter construction. The reason for the relatively low level of savings is the fact that the time during which a highly airtight envelope could be fully utilized would be far from 100 percent of the day. Thus, the amount of time during which the envelope would have to be bypassed by mechanical ventilation would still be considerable.

As pointed out, these findings reflect only broad assessments. They need more quantitative substantiation through adequate statistical analysis. Recommendations are made later in the report for such an analysis as part of a comprehensive study effort.

As shown in Exhibit 5, the "availability" of homes[1] perceived by consumers as having above-average airtightness is about 29% in Eastern and Central Canada. The consumer appeal[2] is about 44%: less than the appeal of extra insulation.

In the absence of a special survey we do not know whether the people who reported above-average airtightness have homes that correspond to the "base case" as defined in our study, or are indeed of tighter construction - in which case they may need ventilation systems to avoid problems. Only one in four respondents who reported above-average airtightness had a ventilation system.

About 20% of the respondents felt that there were health problems associated with increased airtightness, regardless of ventilation systems. Another 10% felt that such problems exist only without installed exhaust systems.

One in three of the people interviewed said that they did not know enough about airtightness: by far the largest percentage of uninformed people among the respondents on all the investigated measures.

Improved Efficiency Furnaces

As shown in Exhibit 5, this measure showed less availability and consumer appeal than insulation. Improved furnaces have actually been installed in 31 percent of the homes surveyed.

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(1) "Availability": actually installed or offered by builder.
(2) "Consumer appeal": actually installed or would have been installed by consumer if it had been available.

None of the installed furnaces were of the "super" efficient type. In fact, respondents, including most of the builders, did not know much about such highly efficient furnaces as condensing gas furnaces.

However, only 20% of the respondents did not know the difference between an improved efficiency and an ordinary furnace.

Since the time of the survey there have been marked increases in the advertising of improved efficiency furnaces. Consequently, the public awareness of these measures is likely to be higher now than it was during the survey.

Heat Pumps

According to Exhibit 5, heat pumps have the lowest availability and consumer appeal among the four measures shown. The figures shown in the Table exclude Montreal, since there all the surveyed new homes had electric heating and, therefore, the statistics regarding heat pumps in Montreal were included under the heading "Improved Furnaces".

Not too surprisingly, in Western Canada, where electricity costs much more than gas, the penetration of heat pumps was found to be zero. There was indication of some consumer appeal but the sample size was too small to derive any conclusions in this respect.

It was surprising, however, that only about one in four people said that they did not know enough about heat pumps or did not think of them. Relatively few respondents volunteered any concerns regarding maintenance problems or short operating life.

Other Measures

Among other energy saving measures, two were noted which have very little or no initial investment costs. One of these is the time controlled thermostat (nighttime setback thermostat or other programmable device) which costs very little, yet can produce considerable energy savings. A great majority of the survey respondents did not seem to find any disadvantages in lower house temperatures during the night and, consequently, it was somewhat surprising that only about one-third of the respondents had such a thermostat. Development of more information on this device to the public and to the builders might have a very significant impact on the penetration of this measure. Although people said that they can easily turn down a thermostat themselves, the effectiveness of a very small investment in an automatic device would still be significant. A properly set time controlled thermostat is estimated to save up to 10 percent of the heating energy in an average house with no high-level insulation or airtightness.

The number of new houses which, fortuitously or by design, have passive solar layouts, was also found to represent approximately one-third of the market. This number is hardly higher than what would result from random planning of subdivisions and indicates that little special effort is made by planners to ensure layouts with maximum solar exposure. The reason for this situation is the apparent fact that houses with favourable layouts from the solar point of view generally do not fetch higher prices, as witnessed by the survey results. This is in spite of the expected energy savings that can be as high as 10 percent for an average house and can be achieved without noticeable capital investment.

It could be theorized that in spite of the fact that homes with passive solar design features are not viewed as more valuable, such features might still represent a potential marketing advantage. The builders have generally not perceived such an advantage in the marketplace, i.e., they did not find that houses with greater solar exposure sold faster than others in a particular subdivision.

At the other end of the spectrum of energy saving measures are devices that can be considered as being at the leading edge of technology. Two of these, the condensing gas furnace and super efficient oil furnace, have already been mentioned and it was stated that the consumers and builders knew generally little about this type of equipment. Our study addressed another device that represents relatively new technology: the air-to-air heat exchanger, which is used to recover heat from the outward air flow of the house and recylces it into the house. Air-to-air heat exchangers require a high level of airtightness so that most of the warm air leaving the home will flow through them. When the heat exchangers are bypassed through excessive leakage they become ineffective.

We found that the public knows little about this device. None of the survey respondents had such a device, and only one of the interviewed builders had ever installed them. However, one builder expressed concern about the reliability of heat exchangers and the lack of their widespread availability in the marketplace. Another builder, the only one who installed heat exchangers, had the manufacturer replace them after a short time because of defects. The perception of the research team is that a greater exposure of the public to these devices, through stepped up advertising by well known manufacturers or distributors and a lower price would be required for greater penetration.

A more sophisticated method of heat recovery is provided by heat pump/heat recovery systems. Such systems can still be considered as being

at the pilot installation stage. According to experience so far they appear to be economically attractive and should be subjected to appropriate field surveys, followed by the dissemination of the test results and their assessment in the media and other publications. At the present time, the public and the builders know very little if anything about these devices and, therefore they were not included in our investigation of barriers to implementation.

Other Information Provided by the Consumer Survey

The consumer survey provided insight into the profile of new home buyers. The results are described in Appendix E. These are a few highlights:

- There is a correlation between the price range of a house and the number of energy saving measures installed, but only at the very low and very high end of the price scale. This means that buyers of larger, high quality (expensive) homes tend to have more energy saving measures installed and buyers of very modest homes tend to install less.

- In the medium price range of houses the survey indicated little correlation between the buyers' incomes and the number of energy saving measures they install. Older people tend to install more measures than younger people.

- People's opinion was divided on the issue of whether energy saving features would add to the resale value of the house or not. The only two measures for which a slight majority expressed a

positive opinion were the improved furnaces and extra insulation.

- Approximately 70% of the respondents had a financial planning horizon of five years or less when deciding to purchase a new house. Only 15% had a planning horizon in excess of 10 years.

- About 90% of the respondents financed their homes through mortgages.

- Two thirds of the new homes sold were built <u>after</u> the sale was made.

V. BARRIERS AND CONSTRAINTS

The previous discussion permits us to draw conclusions regarding the barriers and constraints that might impede or delay the implementation of energy efficient new housing. The conclusions are summarized in the order of the factors identified earlier.

1. ECONOMIC/FINANCIAL CONSIDERATIONS

1.1 The energy saving measures that are not financially attractive to the consumer cannot be expected to penetrate the market in a significant way, since energy saving has no other than financial appeal to most consumers. In the absence of other compelling reasons the only way in which financially unattractive measures can be made attractive is through direct government financial assistance, as discussed further in Chapter VI.

1.2 The financial planning criteria of consumers vary, depending on (1) budget constraints, (2) individual preferences, (3) the belief in escalating energy prices, and (4) personal planning horizons. A reasonable range of these criteria was defined in this study and it was found that the incidence of decisions made by consumers regarding investment in energy saving measures is consistent with that range. This finding led to the conclusion that the consumer's approach to energy saving is overwhelmingly influenced by financial factors and, therefore, the best way to encourage favourable decisions is (1) to improve the consumers' understanding of the financial benefits that can be derived from energy saving measures and (2) to provide financial incentives.

2. INFORMATION NEEDS ON AIRTIGHTNESS

2.1 One area in which information regarding costs and benefits appears to be lacking concerns the most economical levels of airtightness in new homes.

There is also a lack of knowledge in the engineering/ scientific/design community as to:

- the correlations between expected air change rates and other factors, such as details of construction, and the heating and ventilation system, as these factors affect pressure distributions in the house

- the required air change rates of a house under various levels of activity

- the correlation between airtightness test results and expected annual performance.

Builders may be confused by the fact that they would have to spend money on tighter construction to reduce the air flow and, at the same time, spend money on a ventilation system to increase the air flow. (The answer to this apparent paradox is, of course, that the tighter construction and the ventilation system are effective at different times.) The need for more research resulting in appropriate technical guidelines and information in this area is clearly indicated.

2.2 It is recognized that different levels of activity within the house require different air change rates. This means that not only guidelines must be developed but appropriate indica-

tors must be specified that will enable the occupants of the house, or a measuring device, to perceive the need for more ventilation or, conversely, perceive an opportunity for more energy savings.

2.3 There are indications that although most houses built today are tighter than houses built in the past, natural leakage still provides adequate air flows under most circumstances. If a house is built, however, with:

- a higher level of airtightness, or
- without chimneys (such as electrically heated homes or homes with chimney-less super efficient furnaces),

the amounts of time when air change is inadequate may be excessive. At such times the houses require ventilation, preferably through exhaust fans or other systems. The advantage of such systems, as opposed to "natural" leakiness, is their ability to shut down and save energy at those times when the level of activity in the house is low, while still providing the necessary ventilation at other times.

However, since the total time during which extra ventilation is needed is significant, the savings that can be achieved by airtightness levels beyond the "base case" level are estimated to be relatively small. They do not appear therefore to warrant the extra costs associated with high levels of airtightness, unless such airtight construction could be combined with economically priced heat exchange systems. However, as discussed below, the current prices of such systems are still too high to be financially attractive.

2.4 High levels of airtightness can be economical if the exhaust fans could be replaced by attractively priced air-to-air heat exchangers or other heat recovery systems. If their price could be reduced below present levels, such heat recovery systems could make the costs of the extra airtightness worthwhile and, at the same time, guarantee the necessary amount of ventilation at all times.

There appears to be some concern about the reliability of such devices presently on the market. Mass production of air-to-air heat exchangers by large manufacturers and North America-wide marketing and distribution of these devices at lower prices than presently charged would enhance their penetration in the marketplace.

2.5 Heat pump/heat recovery systems are alternatives to air-to-air heat exchangers. While still in the pilot installation stage, they appear to have an excellent chance of being found both technically and financially attractive. They should, therefore, be subjected to more intensive monitoring under a wide range of climatic conditions over sufficient lengths of time to definitively establish their worth.

2.6 Problems of workmanship and the need for more than normal levels of supervision are impediments to the construction of airtight houses. Solution to the problem described under 2.1 may solve part of this problem.

2.7 There are perceptions of health hazards and of structural deterioration associated with high levels or airtightness. Some of these concerns (if associated with insufficient ventilation) are justified. Unjustified concerns would be reduced by the solution to item 2.1.

3. INFORMATION NEEDS ON HEAT PUMPS

3.1 There is some lack of sufficiently widespread general understanding of heat pumps among the trades. It appears that not all leading contractors are familiar with them. There also appears to be a lack of information directed to the public, which would show that the heat pump produces heat from a free renewable energy source that is just as close to being infinite as the energy of the sun and is actually related to it: i.e., the thermal energy of the atmosphere. A proper explanation of the process may divert the attention of groups dedicated to solar energy from trying to harness that energy directly by uneconomical means to harnessing the same energy indirectly, but by economical means: i.e., through the utilization of the energy contained in the atmosphere.

In addition to the explanation of the theoretical background of heat pumps in popular language, actual fact sheets might be published, showing the expected capital and maintenenace costs and the capabilities of heat pump systems, how they can be combined with electric resistance, gas or oil backup heating, and how the air conditioning benefits can give this measure financial advantages. Although little concern was raised by the survey respondents regarding maintenance costs, the study team and advisors associated with the study have such concerns. This issue should preferably be resolved through appropriate targeted surveys and the results should be published. The surveys should also address the concerns expressed by some consumers regarding the contribution of heat pump installations to higher property taxes.

3.2 There appears to be a lack of sufficiently widespread expertise in the installation of heat pumps. Such expertise

appears to be limited to specialized contractors; the lack of knowhow on the part of a builder's regular heating subcontractors appears to be a barrier.

4. SUPPLY OF NEW HOUSES

4.1 There appear to be no impediments resulting from the marketing methods of new housing with regards to those energy saving measures that are financially attractive. The builders' response to the consumers' desires is usually almost immediate. Contrary to practices in the past, the survey showed that today the majority of houses (two-thirds in the survey) is built after the completion of a sale, permitting the installation of any of the energy saving measures a customer may want. Several of these measures may appear on builders' options lists.

4.2 Builders, however, mostly do not use energy saving measures as marketing tools, i.e., most builders (with some exceptions) do not expect competitive advantages from advertising such measures or from persuading customers to install them. Although ready to install such measures at the consumer's request, some builders may not show them on their options list unless they perceive customer interest. The primary target for enhancing the penetration of the measures through better information should therefore be the consumer.

Nevertheless, in parallel with providing the consumer with the financial information required to demonstrate the potential savings produced by certain measures, the same information should also be disseminated to the builders. In this way the builders would be satisfied that they may not be seen by their customers as promoting wasteful investments.

In all fairness, it should be emphasized that none of the builders who were interviewed voiced such fears and they all said that the only criterion which caused any energy saving measures not to be included in their options list was customer indifference.

5. NON-FINANCIAL CONCERNS

5.1 Our survey showed very few concerns of a non-financial nature regarding energy saving measures. Health concerns regarding lack of ventilation have been noted earlier. Solar features are giving rise to minor concerns regarding fading of fabric, the appearance of the house or over-heating in the summer.

6. INSTITUTIONAL FACTORS

6.1 There have been suggestions raised from time to time that many impediments to energy saving installations in new homes could be solved through changes in the building codes. This is a contentious issue. It is difficult to find evidence against the view that the only major objective of installing energy saving measures by a consumer is to save money. Since building codes do not directly address economic advantages or disadvantages, energy saving measures that do not affect health, safety or the protection of the public appear to have no place in the codes.

The argument that energy saving serves broader national goals and, therefore, the buyers of new homes should assume a financial burden through regulatory measures is inequitable. It would be socially unacceptable if a small minority (the new home buyers) were expected to contribute financially, under the compulsion of the building codes, to national energy

self-sufficiency while the majority (people who already own homes) enjoyed the benefits of such self-sufficiency without similar contributions. Energy self-sufficiency clearly benefits all Canadians. In a direct sense, the benefits include: less reliance on foreign oil, more exports of Canadian natural gas and, therefore, lower domesic energy prices. In a more general sense, energy self-sufficiency enhances national independence.

The most equitable way in which the costs of achieving such overall goals can be distributed is to make society, as a whole, carry the burden equally in the short-term. As proposed in Chapter VI, this can be achieved through the subsidization of energy saving meaures when such subsidies are justified from the public perspective.

6.2 Electrical and gas utilities play a significant role in the supply of energy for home heating. The issues of pricing electricity and natural gas for residential consumption are much broader than the scope of this study and are not analyzed in this report, either as means of enhancing the use of energy saving measures or as barriers to it. Several general comments can be made, however, which are helpful in the full evaluation of energy efficiency in new housing.

In the majority of Canadian provinces, including the three largest, a substantial portion of the electrical energy is generated by hydro or nuclear generation. Since space heating must be provided at those times when the overall provincial power demand is at its peak, any heating load saved would save the costs of generating the peak portion of energy. The cost of generating this portion is usually higher than the average rate at which electrical energy is sold.

The savings accruing to society as a whole from the energy conservation measures are therefore significantly higher than the savings experienced by the individual consumer in electricity bills. This factor is discussed in connection with potential government roles in Chapter VI.

Another issue is the structure of utility rates. Declining consumption usually increases the utility's capital cost per unit of energy sold. In order to prevent this factor from becoming a barrier to the installation of energy saving measures, rate regulations should ensure that any rate increases resulting from reduced or more peaked consumption should be spread universally over the system and not penalize those individuals who have actually implemented the most effective energy conservation measures. The regulatory process makes it possible to monitor and influence the approval of rate structures that do not constitute a barrier to the implementation of energy conservation in new housing. Government can make appropriate representations in the regulatory process to draw attention to this public perspective.

The fairness of this type of rate averaging can be supported by the same principle that was discussed earlier in connection with the issue of building codes: a few individuals should not be forced to carry the burden for the provision of a benefit that accrues to all people.

VI. GOVERNMENT ROLES

The steps that the Federal Government can take to enhance the penetration of energy saving measures can be divided into several categories. Based on the findings summarized in Chapter V, the following three major groups of practical government action can be identified:

1. Dissemination of information.

2. Research and development activities, followed by the dissemination of information.

3. Financial assistance.

The most appropriate approach that might be applied to each energy saving measure investigated in this study varies from measure to measure, depending on the state of the art and on the balance of the costs and benefits associated with the measure. The steps that appear to be the most logical on the basis of the findings of this study are summarized below.

1. DISSEMINATION OF INFORMATION

There are several energy saving measures that are currently being used in new housing and do not appear to be linked to any unanswered questions of substantial significance at the technical level. These are:

- insulation
- improved efficiency gas and oil furnaces
- time-controlled thermostats
- passive solar layouts.

The penetration of these measures in the marketplace could be significantly enhanced through the dissemination of information to builders, real estate agents, mortgage lending institutions and other agencies through brochures and other material. The brochures would provide basic information to the agencies and to their customers on the economies that can be achieved through various energy saving measures.

The brochures would describe the various levels of application for each measure and show the incremental investment costs that would be justified by the expected savings if the measures were installed in new homes of different types and sizes. The booklets would provide an estimate of the savings in energy bills that would be achieved for typical geographic areas in Canada under a set of future economic conditions and would provide information on the relations between these savings and present investment.

To define the economic conditions it would probably be sufficient to specify two parameters: the mortgage interest rate and the expected rate of inflation in energy prices. Tables could then be provided for, say, mortgage interest rates of 9, 11 and 13 percent and annual fuel price increases of, say, 4, 7 and 10 percent.

The booklets would not use "economic jargon", e.g. references to such terms as net present value, rate of return on investment, etc. They would simply show, for easy understanding, the increase in annual mortgage payments that would occur as the result of investment in an energy saving measure and the offsetting savings in energy bills, for each of the ensuing 5 years. The booklets would have to be re-issued each year, to follow any changes in the economic parameters.

Expression of consumer interest for such a booklet is almost guaranteed. A cautionary note indicating the dependence of the data on the quality and state of maintenance of the individual products and on

individual lifestyles must, of course, be included in the booklets. However, the need for such cautionary notes did not prevent the federal government from issuing, for example, booklets on the typical fuel consumption of passenger cars, although it is well known that the actual consumption figures depend greatly on engine tuning, maintenance and driving habits.

Another important set of information that Government can provide is an annual publication of average fuel expenses in various cities for homes of various sizes and types. This information would enable home owners to evaluate their heating costs vis-a-vis regional averages.

This type of information would supplement the economic data discussed earlier, allowing each new home owner to make his own evaluation year after year. As in most cases, this evaluation is expected to produce positive results, it is likely that the amounts of the actually achieved savings in heating expenses would be widely discussed among home owners. Such exchanges of information would certainly encourage the installation of more energy saving measures. Most importantly, the ability to quantify the savings would enable the seller of an existing house to use the demonstrated savings as a selling point. Consequently, the buyers of new homes would be more confident that they could recapture the investment costs of any energy saving measures if they were to sell their homes after a few years.

2. RESEARCH AND DEVELOPMENT, FOLLOWED BY THE DISSEMINATION OF INFORMATION

Since the importance of energy savings has not been fully recognized in Canada until the latter part of the 1970's, there are several energy saving measures that are still at relatively early stages of development. Although calculations on paper, laboratory tests and pilot installations in the field have shown great promise, further validation

of the net benefits that can be derived from these measures is required before Government can issue brochures describing their expected performance. While legally such brochures do not imply government endorsement or guarantees, recent experience with, for example, urea formaldehyde insulation has proved that perceived encouragement by Government to use a particular product can be construed as an assumption of responsibility.

Since new housing is responsible for a relatively small percentage of energy consumption it will take at least a generation before any steps taken today will have a significant impact on Canada's energy balance. For that reason, there appears to be no strong reason for rushing into premature conclusions regarding certain measures. The completion of all necessary and conclusive technical and economic evaluations appears to be warranted before Government can put its full weight behind the promotion and potential subsidization of the measures in question.

There are several types of activities that may be necessary to validate the benefits of a particular energy saving measure to the full satisfaction of Government. Depending on the depth of experience and understanding related to a measure these types of activities are:

(a) Surveys of existing installations.
(b) Monitoring of pilot installations.
(c) Laboratory testing and evaluations.
(d) Development of guidelines.

Comments are made below in relation to each measure that appears to require further surveys or research.

Heat Pumps

Of the energy saving measures evaluated in this study, heat pumps require relatively little further evaluation. As noted in Chapter V, it appears that there is insufficient knowledge about the life cycle operating costs of these devices. A comprehensive survey of a representative number of installations with sufficient past history (and/or updating of past surveys) is required to verify expected maintenance costs, including estimates of the time at which maintenance costs would rise to a level at which replacement would be justified. Although field data for heat pumps that were manufactured ten to fifteen years ago may not be fully representative of those manufactured today, the application of appropriate judgment to the survey results would allow the estimation of future maintenance costs. Such judgment can be exercised by technical researchers in collaboration with the manufacturers who could indicate the improvements they have applied in recent years to the parts that most commonly fail.

The suggested survey program would be followed by a thorough evaluation and the publication of an information brochure that would contain a popular description of the principles and the expected economic advantages of heat pumps. The format and distribution of the brochures could be similar to those described earlier.

Air-to-Air Heat Exchangers and Super Efficient Furnaces

Surveys of existing installations are suitable for the evaluation of mature products. For relatively new products, a more comprehensive method of performance evaluation may be more appropriate, such as the monitoring of pilot installations. This method differs from simple surveys by letting the users know in advance that their equipment will be monitored. Because of their relatively

short history, this type of validation appears to be necessary for air-to-air heat exchangers, condensing gas furnaces and super efficient oil furnaces.

A well designed program of field monitoring appears to be necessary before Government can fully evaluate the performance of these devices after several years of service. The process of validation foreseen here would include a program of replacing some of the equipment at government expense and examining any deterioration that might have taken place in the devices removed from service. This approach would enable government researchers to estimate the useful life of the equipment and the future costs of maintenance. Since industry would certainly benefit from this program some form of cost sharing between the manufacturers and the government could be negotiated.

Heat Pump/Heat Recovery Systems

The heat pump/heat recovery system, which has the same function as an air-to-air heat exchanger but has an efficiency greater than one, is another "new" development. The experience with this type of system is even shorter than the experience with air-to-air heat exchangers or condensing furnaces and has, therefore, not been included in the measures examined in this study. The system may still require some research including, if necessary, laboratory tests and evaluations to predict its maintenance needs and any potential operating problems. The results of this work would have to be published in the technical literature and be subjected to comments from the international engineering community. In parallel with this work, the system also requires more widespread publicity in the popular press so that consumers become interested in it and begin to understand its quite ingenious principles.

Canada's Opportunity

Canada has a unique opportunity to be in the forefront of development and mass manufacturing of the three types of equipment described above: the air-to-air heat exchangers, the super efficient furnaces and the heat pump/heat recovery systems. Canada's climate automatically creates a large home market for these devices. This market may be almost equal in size to that in the United States if only those parts of North America are considered that have a climate similar to that of Canada. The products involved certainly appear to be of the type that would merit government assistance for the process of validation, followed by commercial promotion backed up by government-disseminated information.

Airtightness and Ventilation Requirements

A problem closely associated with the devices above (air-to-air heat exchangers, chimney-less furnaces and heat pump/heat recovery systems) is the need for a thorough understanding of the air change rates and of the relationships associated with pressure distributions in enclosed spaces. The requirements related to comfort, health and to the integrity of structures must also be defined more precisely.

It is well understood that the objective of energy conservation through the minimization of the volume of warm air that leaves a house on the one hand and the requirements for fresh air on the other are in conflict and, therefore, the level of air conservation cannot be increased beyond a certain level. Guidelines are required to minimize the risks of health and safety as well as risks of damage associated with interstatial condensation which cannot be measured in terms of energy savings. As noted in Chapter V, such guidelines have not been satisfactorily established

and appear to require stepped-up investigations on the part of the scientific and engineering community.

The design of appropriate accelerated research programs in this area, sponsored or conducted by government agencies and academic institutions, appears advisable. These programs would deal with issues of health and comfort as well as with the impact of condensation on structures. The development of appropriate guidelines will ensure that in the overall effort of maximizing energy savings, the issue of potential side-effects is not overlooked.

3. FINANCIAL ASSISTANCE

In addition to the savings in energy bills enjoyed by the individual consumers through increased energy efficiency in new housing, Canadian society, as a whole, can enjoy further savings. Every cubic metre of natural gas saved by a Canadian consumer allows Canada to export more gas to the United States at prices substantially above those charged to domestic consumers. Each litre of oil saved reduces Canada's crude oil imports and saves the government and the consumers the import subsidy that makes up the difference between the world price of oil and the lower domestic price. Each kilowatt-hour of electrical energy saved by the consumer reduces the amount of energy that has to be produced through the most costly form of generation in the system, causing the savings in costs to the utility to be greater than the individual consumer's savings.

The analysis in this study suggests that, with a good approximation, for every dollar saved by the individual consumer, society saves an additional 25 cents in terms of the social costs described above. If some of these savings were passed on to the individual consumers, their decision to install energy saving measures would be encouraged and the

total savings to the individual consumer as well as to society as a whole would be increased.

The most effective method for passing on the social savings from Government to the individual consumers would be the payment of immediate grants. This approach would recognise the major difficulty faced by the individual consumer when making a decision regarding investment in an energy saving measure: the need for comparing a known immediate expense with a stream of unknown future benefits. Government assistance that is not immediate would only increase the complexity of such comparisons instead of helping the consumer in reducing the gap of uncertainty.

It is shown in Appendix B that from a purely social point of view (i.e., ignoring differences between levels of government), Government can afford to pay the consumer a subsidy extending to a maximum of about 30 percent of the extra investment(1) required by an energy saving measure.

To illustrate this point, assume an investment of $1,000. As shown in Appendix B, a consumer with the greatest propensity to invest in energy saving measures would be willing to invest $700 if his or her own savings in the first year were at least $40. (This is the amount that corresponds to an investment/saving ratio of 17.5, which was assumed to be the maximum that would still make the investment financially attractive to the most willing consumer). It is further shown in Appendix B that for such an annual saving accruing to the consumer, the additional long term benefits accruing to the public at large would justify an additional "societal" investment of $300 in the energy saving measure. Government, on society's behalf, can therefore afford to add this amount to the $700 provided by the consumer.

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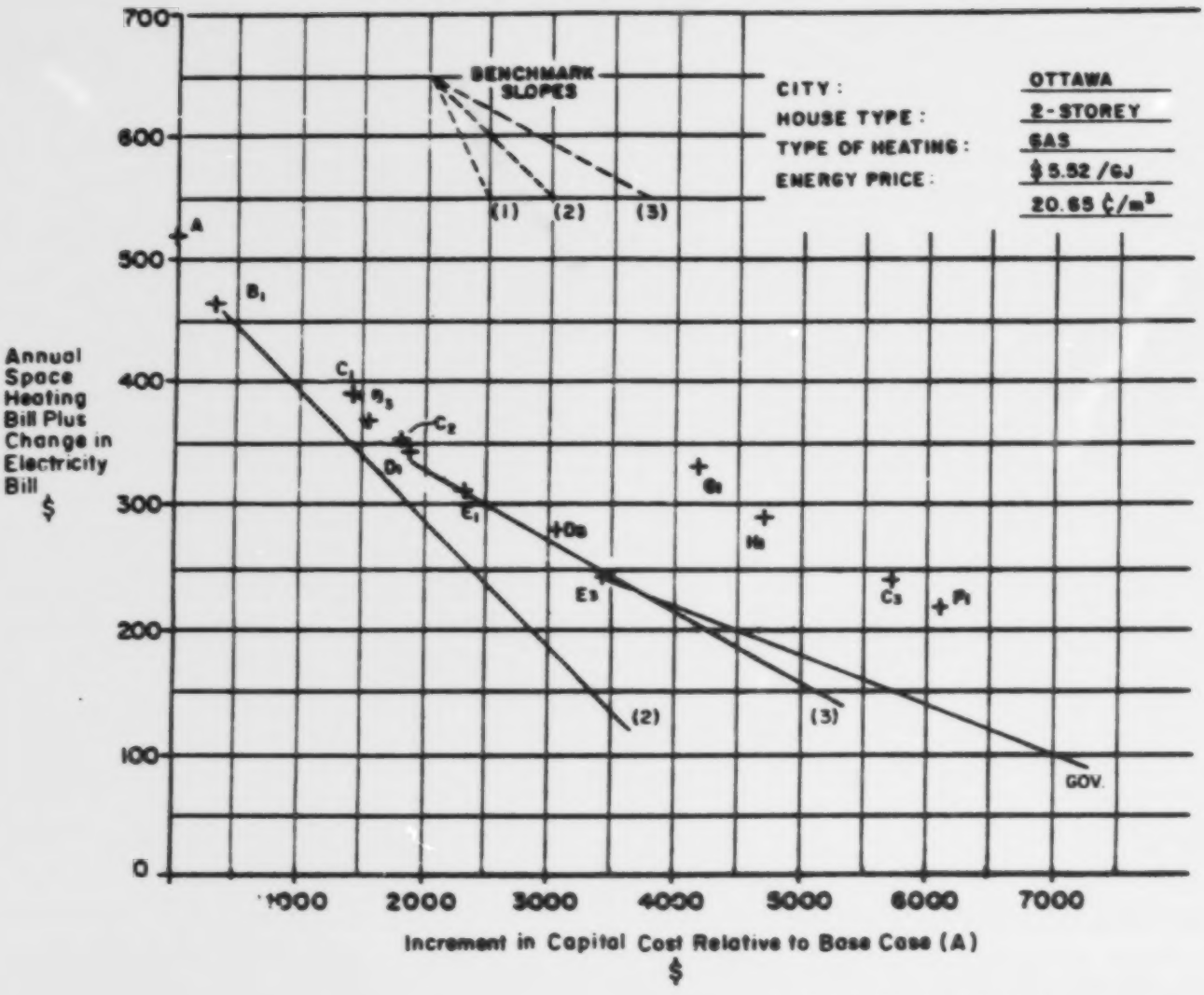
(1) "Extra" investment means the difference between the investment incorporating the energy saving measure and the "base case" investment that would have been made anyway.

EXHIBIT 8

SAVINGS / INVESTMENT GRAPH



A	BASE CASE
B1	IMPROVED FURNACE
B3	SUPER EFFICIENT FURNACE
C1	INSULATION "1"
C2	INSULATION "2"
C3	INSULATION "3"
D1	INSULATION "1" + IMPROVED FURNACE
D3	INSULATION "1" + SUPER EFFICIENT FURNACE
E1	INSULATION "2" + IMPROVED FURNACE
E3	INSULATION "2" + SUPER EFFICIENT FURNACE
F1	INSULATION "3" + IMPROVED FURNACE
G1	SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1	SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1):	5.0 (SHORTEST TERM VIEW)
(2):	10.0 (MEDIUM TERM VIEW)
(3):	17.5 (LONGEST TERM VIEW)
GOV:	25.0 (GOVERNMENT PAYS 30% OF CAPITAL COSTS)

If government paid 30% of the extra measures and the annual savings were in fact higher than the minimum amounts that would provide financial justification, the individual consumer and society would both benefit from the net savings and share them in proportion to their contribution to the capital costs.

It can be shown, however, that it is economically not justified for government to back all energy saving measures indiscriminately. Exhibit 6, on page 56, is identical to Exhibit 2, but shows a "benchmark slope" corresponding to the financial returns expected from a "joint" investment by the consumer and Government. The slope represents a "blended" investment/saving ratio of 25, which corresponds to a ratio of 17.5 seen by a consumer, who assumes 70% of the total investment, and a ratio of 32 seen by government, which assumes 30% of the total investment.

It is clear that compared with Option E_3 ("Level 2" Insulation plus Condensing Gas Furnace), Options C_3, F_1, G_1 or H_1 (Options including "Level 3" Insulation or Heat Exchangers) are uneconomical. These options clearly use more or only slightly less energy than the considerably cheaper E_3 option.

The financial incentives described above are also applicable to the retrofit sector, considering particularly that houses in that sector will still outnumber new houses for many years to come. The CHIP program recognized the public benefits derived from energy savings in houses and the impacts of incentives. However, the investment/saving ratios are quite different in older houses and the quantitative conclusions of this study do not apply to that sector.

Whereas it is recognized that the government funds needed for both the validation programs described in the previous sub-section and the investment cost-sharing programs described in this sub-section could be

EXHIBIT 7

SUGGESTED GOVERNMENT ACTION

MEASURE	FINANCIAL INFORMATION	RESEARCH LEADING TO GUIDELINES	FIELD AND LABORATORY TESTS	PERFORMANCE SURVEYS	GRANTS	
					R&D	CONSUMERS
Insulation	●	-	-	-	-	●
Airtightness	-	●	-	-	-	-
Improved Furnaces	●	-	-	-	-	●
Super Efficient Furnaces	●	●	-	-	-	●
Heat Recovery Systems	-	-	●	-	●	-
Heat Pumps	●	-	-	●	-	●
Total Systems	-	-	-	●(1)	-	-

(1) Annual reports on average heating bills by home size, type and city.

substantial, the cost-effectiveness of the programs could also be very high. It appears to be a valid opinion that funds from oil and gas tax revenues, originally earmarked for the now-cancelled megaprojects, could very effectively be spent on these suggested programs which have at least two advantages over the programs related to the megaprojects:

- Benefits would be achieved regardless of future fuel prices, since fuel prices are already high enough to justify the programs.

- The expenditures can be made in continuous increments, with benefits following promptly and at the same rate as the rate of expenditures made.

The benefits of the suggested assistance programs, in terms of reducing the demand for depleting conventional energy resources, would be greater per dollar investment, less risky and more immediate than the benefits gained from the development of new or alternate energy sources.

The potential roles of Government in encouraging the implementation of energy saving measures in new homes, as identified in this Report are summarized in tabular form in Exhibit 7, on Page 58.

Volume

2

CMHC
Canada Mortgage
and Housing Corporation

SCHL
Societe canadienne
d'hypotheques et de logement

SYSTEMS VIEW OF ENERGY EFFICIENCY IN NEW HOUSING

Volume II
Appendices A - G

Research Division
Canada Mortgage and Housing Corporation

APPENDIX A

MEASURES

APPENDIX A

MEASURES

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APPENDIX A

MEASURES

INTRODUCTION

The following measures are described in this appendix:

- Insulation
- Fuel Fired Furnaces
- Electric Furnaces
- Heat Pumps
- Airtightness
- Exhaust Systems
- Air to Air Heat Exchangers
- Passive Solar Layout and Storage
- Nighttime Setback Thermostats

All of the measures are generally available to the public. Several of the measures can be installed in different amounts or at different "levels". These levels are defined and described.

Tables for each measure are included which give the cost of the base case and the cost increment as the amount or "level" of the measure is increased. The major parameters of the measures at each level are also provided. Costs of conventional furnaces are included to provide a basis for comparison with the improved efficiency furnaces.

Costs to the consumer were estimated by adding 1.3 times the labour costs to the costs of materials and applying a markup of 35 percent to the resulting

amount for builders' and subcontractors' financing, profits and risks. The total costs are shown in this Appendix.

All prices and costs shown in this Appendix are in 1983 dollars.

The costs shown for the various measures in the Exhibits of this Appendix are those applicable to Toronto and are shown as examples. Appropriate adjustments were made for other cities; however, the cost differences are not very significant and the figures shown for Toronto provide an adequate overview of the cost relationships among the various measures.

Exhibits A-1 to A-15 at the end of this Appendix show the major parameters used for each measure in this study.

INSULATION LEVELS

R values are effective R values; i.e., they include interior finish, cladding, air films, etc., plus effect of heat loss through framing. They are in °C m^2/watt (°F ft^2/btu in brackets).

Base Case

- A judgemental national average of typical 1979 practice as determined in a survey carried out by CMHC

- the roof is attic type with R4.9/216 mm, fibreglass batts; R = 5.0 (28)

- the walls are 38 x 89 stud framing with normal interior finish, sheathing, cladding, etc., and filled with R2.1/89 mm fibreglass batts; R = 2.5 (14) overall

- the foundation walls are insulated with fiberglass batts in 38 x 64 strapping covered with gypsum board; the insulation extends only to 600 mm below-grade, R = 1.7 (10) /600 mm

- the windows are double glazed.

Level 1

- ceiling - about 250 mm of cellulose fibre, R = 6.2 (35)
- walls - same as Base Case but sheathing replaced with extruded polystyrene; R = 3.1 (17) overall

- foundation walls - same as Base Case but extended all the way down to the basement floor; R = 1.7 (10)/1790 mm

- windows - triple glazed.

Level 2

- ceiling - about 300 mm of cellulose fibre; R = 7.6 (43)

- walls - same as Level 1 but thicker extruded polystyrene R = 3.4 (19) overall

- foundation walls - same as Level 1 but 38 x 64 framing is set out from wall to accomodate thicker batts; R = 3.1 (17)/1790 mm

- windows triple glazed.

Level 3

- ceiling - about 400 mm cellulose fibre, R = 10.6 (60)

- walls - 38 x 140 studs filled with fiberglass batts plus 38 x 64 horizontal strapping filled with batts on interior (cost includes allowance for loss of building area) R = 6.1 (34)

- foundation walls - same as Level 2 but framing set out further to accomodate thicker batts; R = 5.2 (29)

- basement floor - 32 mm of extruded polystyrene beneath slab

- windows - quadruple glazed.

FUEL-FIRED FURNACES

Size: Generally the furnace capacities listed in the CMHC-2 data base were too large for the energy efficient houses contemplated in this study. Therefore it was necessary to postulate smaller sizes and to calculate costs for these sizes by straight line extrapolation of the cost-capacity relationship of the last few listed capacities.

Features: Gas - improved efficiency: - electronic ignition
- flue damper

- condensing: - large heat exchange surface recovers virtually all sensible heat from flue gas and condenses water vapour to also recover latent heat.

Oil - improved efficiency: - flue damper
- flame retention head

- super efficient: - similar to condensing head

Maintenance: Maintenace costs in excess of those applicable to conventional furnaces were established on an annual average basis. It was assumed that home buyers would not perceive differences in life expectancy between different types of furnaces.

ELECTRIC FURNACES

Assumed to be 100% efficient.

Since it was not the objective of the study to provide inter-energy evaluations it was not necessary to include prices for electric baseboard heating (also assumed to be 100% efficient). Electric furnaces are more directly comparable with fuel-fired furnaces than baseboard heaters by non-economic criteria.

Maintenance costs were assumed to be insignificant.

CONVENTIONAL EXTERIOR AIR SOURCE HEAT PUMPS

Heat pump capacity was chosen using what could be considered normal industry practice.

- match heat pump nominal cooling capacity to house heating load at January 2 1/2% temperature

- check that heat pump heating capacity at -10°C is approximately equal to house heating load at -10°C (i.e., the balance temperature is -10°C) and try another size pump if necessary to achieve this condition

- calculate heat pump and back-up energy consumption separately from main CMCH-2 program using the modified bin procedure developed by D. Cane of DBR/NRC. A rather complex adjustment procedure was used to ensure compatibility between the two calculation methods (i.e., "bin" and CMHC-2).

Typical heat pump performance data were obtained from D. Cane. Although not shown on the consuming data sheets, these included detailed tables of C.O.P. versus exterior temperature for all capacities.

Heat pump costs, which were obtained from a manufacturer, are reduced by the cost of equivalent air conditioners. This is why there is no consistent relationship between capacity and cost.

Heat pump maintenance costs were estimated on an annual average basis. The fact that heat pump maintenance costs may increase after 12 to 15 years to a point when complete replacement would be preferable, was disregarded since no reliable data exist to take this factor appropriately into consideration and the present value of a potential future replacement cost would normally not be considered by a home buyer.

AIRTIGHTNESS LEVELS

Base Case

- assumes 0.05 mm (2 mil) polyethylene vapour barrier with strips over partition ends and tops but minimal overlap (100 mm or less) at joints and carelessly executed

- no attempt to seal around plumbing stacks, chimneys, light fixtures, receptacles, etc.

Level 1

- assumes 0.15 mm (6 mil) polyethylene vapour barrier with strips over tops and end of partitions, reasonably carefully lapped over 400 to 600 mm and lapped onto window and door frames

- above-mentioned points sealed with gaskets, sealant or polyethylene.

Level 2

- assumes 0.15 mm polyethylene vapour barrier very carefully sealed at all joints and interruptions with acoustic sealant (cost premium mainly reflects extra time).

Calculations

- although no relationship has been established between airtightness and air leakage, in the absence of anything else, the average air change rate over the heating season (air changes per hour) was assumed to be 1/10 of the air change rate at 50 Pa test pressure

- it was assumed that any house tighter than the base case must have mechanical ventilation.

HEAT EXCHANGERS

Since air-to-air heat exchangers have both exhaust and intake fans they were assumed not to affect the inside/outside pressure distribution and, therefore, not to affect the air leakage. This means that the accidental air leakage occurs as before without heat recovery and heat is recovered only from the added air change going through the heat exchanger.

Example:

If a 71 l/s heat exchanger were installed in a house with Level 2 airtightness (n_{50} = 1 ach) the total air change would be 0.1 ach + 71 l/s and 80% of the heat loss in the 71 l/s would be recovered.

The fans of the heat exchanger were assumed to consume 4 kWh/day for the 71 l/s model over a 240 to 255 day heating season (depending on envelope).

PASSIVE SOLAR LAYOUT AND STORAGE

Maximum south window areas were matched to the internal storage capacity using graphs from the Guide to Energy Efficiency in Masonry and Concrete Buildings, prepared for the Masonry Council of Canada. Using interpolation for "medium", this resulted in the following window areas:

Window Areas (m^2):

	S	(E N W)	TOTAL
BASE	4	11	15
LEVEL 1	15	2	17
LEVEL 2	18	18	20

No cost was assumed for shifting the windows around the house. In fact, the cost of windows was assumed to be about equal to that of equivalent wall areas, so that the slight increase in total window area for this case over the base has no charge attached.

NIGHTTIME SETBACK THERMOSTAT

One of the simple automatic types was assumed.

It was assumed to reduce the temperature from 20°C to 14°C for 8 hours each day.

Since the temperature in highly insulated houses will not drop very rapidly, this measure may be less effective if combined with high insulation levels than when used in houses with "base case" insulation.

EXHIBIT A-1

TORONTO COSTS

FOR

ENERGY CONSERVING MEASURES

(February 1, 1983)

INSULATION LEVELS

LEVEL	R VALUES					Cost Increment**
	Roof	Walls	Fdn. Walls	Basement Floor	Windows	($)
Base Case	5.0	2.5	1.7/600*	0	0.3	0
1	6.2	3.1	1.7/1790	0	0.5	1436
2	7.6	3.4	3.1/1790	0	0.5	1923
3	10.6	6.1	5.2/1790	1.1	0.65	5758

*mm below grade

**This is calculated for each house type using the CHC-2 Energy Analysis Program 1982 cost data base. Figures shown are for a 125 m^2 2 storey detached house.

EXHIBIT A-2

CONVENTIONAL GAS FURNACES

(BASE CASE)

Capacity (kW)	Seasonal Efficiency (%)	Cost ($) (3)
16	62	1709 (1)
12	62	1684 (1)
10	62	1653 (1)
8	62	1641 (2)

References:

(1) Based on data supplied by Lennox.

(2) Postulated, based on costs of larger sizes.

(3) Includes $366 for chimney plus added framing to accomodate chimney.

EXHIBIT A-3

IMPROVED EFFICIENCY GAS FURNACES

Capacity (kW)	Seasonal Efficiency (%)	Cost ($) (3)
16	70	2100 (1)
12	70	2080 (1)
10	70	2050 (1)
8	70	2037 (2)

Maintenance cost above base case: $5 per year

Reference:

(1) Based on builders' cost increment over conventional furnaces suggested by Consumers Gas.

(2) Postulated, based on costs of larger sizes.

(3) Include $366 for chimney plus added framing to accomodate chimney.

EXHIBIT A-4

CONDENSING GAS FURNACES

Capacity (kW)	Seasonal Efficiency (%)	Cost ($)
15	90	3325 (1)
12	90	3300 (1)
10	90	3270 (1)
8	90	3257 (2)

Maintenance cost above base case: $10 per year

Reference:

(1) Based on builders' cost increment over conventional furnaces suggested by Consumers Gas.

(2) Postulated, based on costs of larger sizes.

EXHIBIT A-5

CONVENTIONAL OIL FURNACES

(BASE CASE)

Capacity (kW)	Seasonal Efficiency (%)	Cost ($) (3)
16	65	2172 (1)
12	65	2123 (2)
10	65	2111 (2)
8	65	2099 (2)

References:

(1) Based on cost from Esso Home Comfort Centre.

(2) Postulated, based on costs of larger sizes.

(3) Includes $366 for chimney plus added framing to accomodate chimney.

EXHIBIT A-6

IMPROVED EFFICIENCY OIL FURNACES

Capacity (kW)	Seasonal Efficiency (%)	Cost ($) (3)
16	75	2318 (1)
12	75	2257 (2)
10	75	2245 (2)
8	75	2223 (2)

Reference:

(1) Data base for CMHC-2 Energy Analysis Program.

(2) Postulated, based on costs of larger sizes.

(3) Includes $366 for chimney plus added framing to accomodate chimney.

EXHIBIT A-7

SUPER EFFICIENT OIL FURNACES

Capacity (kW)	Seasonal Efficiency (%)	Cost ($)
15	93	3772 (1)
12	93	3723 (1)
10	93	3711 (1)
8	93	3699 (1)

Maintenance cost above base case: $10 per year

References:

(1) Based on condensing gas furnace cost increment over conventional gas furnace added to cost of conventional oil furance.

EXHIBIT A-8

ELECTRIC FURNACES

Capacity (kW)	Cost ($)
16	1220
12	1220
10	1220
8	1220

References:

(1) Cost from Ontario Hydro.

(2) Includes cost of 200 amp. service.

EXHIBIT A-9

CONVENTIONAL EXTERIOR AIR SOURCE

HEAT PUMP/RESISTANCE HEATING PACKAGES

Capacity** (kW)	Cost * ($)
10.5 (3 tons)	2074
8.8 (2.5 tons)	1952
7.0 (2.0 tons)	1830
5.3 (1.5 tons)	1952

Average maintenance cost above base case: $70 per year

* Costs are reduced by cost of equivalent air conditioner and are additional to electric furnace costs (shown in Exhibit A-8).

** Equivalent air conditioner ratings.

Reference:

- Performance data supplied by D. Cane, DBR/NRC.

- Cost data supplied by manufacturer.

EXHIBIT A-10

CONVENTIONAL EXTERIOR AIR SOURCE ADD-ON HEAT PUMPS

FOR USE WITH FUEL-FIRED FURNACES

Capacity** (kW)	Cost* ($)
10.5 (3 tons)	2010
8.8 (2.5 tons)	1890
7.0 (2 tons)	2010
5.3 (1.5 tons)	2070

Average maintenance cost over base case: $70 per year

* Costs are reduced by cost of equivalent air conditioner, and are additional to gas furnace costs (shown in Exhibit A-2).

** Equivalent air conditioner ratings.

Reference:

- Performance data supplied by D. Cane, DBK/NRC.

- Cost data supplied by manufacturer.

EXHIBIT A-11

AIRTIGHTNESS LEVELS

LEVEL	Air Change Per Hour at 50 Pa	Cost Increment ($)
Base Case	4	-
1	2	500 (1)
2	1	820 (2)

Note: "Level 1" and 'Level 2" require one of the exhaust systems on following pages.

References:

(1) Evaluation of Construction Details and Procedures to Improve the Airtightness of Low Rise Residential Construction Scanada for DBR/NRC, 1980.

(2) Cost of Energy Conservation Measures for New Housing
Dumont & Orr
DBR/NRC Building Research Note No. 176, Sept. 1981
(cost modified by Scanada formula).

EXHIBIT A-12

EXHAUST SYSTEMS

Capacity (l/s)	Cost Increment ($)
71	160

Reference:

Data supplied by manufacturers and contractors.

EXHIBIT A-13

AIR-TO-AIR HEAT EXCHANGERS

Capacity (l/s)	Recovery (%)	Cost ($)
71	80	1620

Note:
Requires "Level 2" airtightness

References:

Costs data supplied by contractor who supplies and installs heat exchangers.

EXHIBIT A-14

PASSIVE SOLAR STORAGE CAPACITY

Level	Internal Mass	Cost Increment ($)
Base Case	Low	----
1	Medium	1000
2	High	2000

Reference:

Hollow Core Slabs as Storage Medium for Passive Solar Energy, Scanada for Canadian Prestressed Concrete Institute, 1980.

EXHIBIT A-15

NIGHTTIME SETBACK THERMOSTAT

Nighttime Setback Thermostat
Reduction in degree days - 300
Cost - $100

References:

HUDAC Energy Saver Program: Background Information on Payback Analysis
Scanada for HUDAC, Nov. 1980.

APPENDIX B

ECONOMIC FACTORS

APPENDIX B

ECONOMIC FACTORS

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APPENDIX B

ECONOMIC FACTORS

OVERVIEW

The assessment of new houses from the buyer's financial perspective includes the consideration of several factors relating to the affordability of both the initial investment and of future carrying charges. These are the most important factors:

- Budget constraints
- Financing methods, including the consideration of interest rates
- Energy prices
- Planning horizons.

The economics of energy efficient new houses are discussed below from the private and the public perspective.

The Private Perspective

The private perspective varies with the type of new home buyer, who can be classified by several criteria. Two of these criteria are:

- the constraints on the buyers' budget; and
- the method of financing.

With respect to budget constraints, there are buyers who:

- have flexible budgets, i.e., they are able to spend more money on energy saving features in addition to other features they have selected if they believe this to be a worthwhile expenditure of funds; or

- have limited funds, i.e., when they select an energy saving measure they would have to give up some other feature in the new house.

Within each of these two groups, we shall distinguish between two sub-groups with respect to financing. We shall discuss the perspective of a new home buyer, who:

- finances a house primarily through a mortgage loan; or

- finances the house primarily by making a cash investment.

The decision-making processes of these buyer groups are different as discussed later in this Appendix.

The Public Perspective

The public perspective differs from the private perspective in three major aspects:

- it includes the extra revenue to Canada resulting from the sale of natural gas, that has been conserved by Canadians, to consumers of the United States;

- it includes the savings to Canadians resulting from the reduction of oil imports or of oil derived from high-cost sources;

- it considers the impact of reduced electric heating demand on the reduction of peak capacity requirements; this capacity consists of the highest-cost generating units and, therefore, the savings per kilowatthour are greater than calculated on the basis of the average electricity rates paid by the consumer.

The public benefits above are spread over all the energy consumers of Canada, instead of accruing only to the individuals who install the energy saving measures.

ENERGY PRICES

Our assumptions regarding energy prices are based on the "Energy Supply/Demand Outlook" published by the Market Analysis and Statistics Division of the Department of Energy, Mines and Resources, issued in June, 1982. Exhibit B-1 shows the projected price indices in real dollars for 1982, 1987 and 2000, for natural gas, electricity and heating oil, in five provinces of Canada. All prices are average residential prices at the consumer level and relate to quantities of fuel representing the same energy content, e.g., to such units as $/gigajoule.

Since this study was only intended to examine barriers to energy efficiency in new housing and was not meant to provide a comprehensive evaluation of energy alternatives in Canada, only those provinces are addressed in this Appendix in which consumers were surveyed, in order to compare their actual decisions to the results of objective economic analysis.

EXHIBIT B-1

RESIDENTIAL FUEL PRICE INDICES
(Real Price per Gigajoule)

1982 Ontario Average Natural Gas Price = 100

	NATURAL GAS*			ELECTRICITY			OIL*		
	1982	1987	2000	1982	1987	2000	1982	1987	2000
British Columbia	81.5	82.9	128.5	190.0	234.3	254.9	145.1	156.0	206.0
Alberta	66.5	69.0	110.4	163.2	175.5	186.3	141.4	152.8	202.7
Ontario	100.0	108.3	146.0	192.1	236.6	267.2	143.9	155.7	204.6
Quebec	105.6	114.6	153.2	188.8	233.5	260.3	147.0	158.2	206.9
Nova Scotia	n/a	130.4	170.7	244.1	286.7	351.4	144.3	157.4	208.5

* Unit price of delivered heat = 1.61 times price shown

Natural Gas

The 1982 average natural gas price in Ontario was chosen as the base of comparison, represented by 100 in the Exhibit. The corresponding actual price is $5.19 per gigajoule. This is equivalent to 19.8 cents per cubic metre, which is a "mean" price, not reflecting the usual rate scale that declines with increasing consumption. For the purpose of economic analysis viewed from the private perspective, the marginal price of energy should be used, which is the price paid for energy saved. At the end of 1982 this price was approximately 21.0 cents per cubic metre in Ontario.

Exhibit B-1 shows that natural gas costs much less in Western Canada, particularly in Alberta, than in Eastern Canada. This is the result not only of transportation cost differentials, but also of the fact that the National Energy Policy does not apply to internal pricing within the province of Alberta.

Exhibit B-1 indicates that in the long term, real natural gas prices are expected to increase approximately at an average annual rate of 2.0% in Eastern Canada, i.e. at a rate that is approximately two percentage points above that of inflation. The projected increase is greater in Western Canada, which would bring the provincial prices somewhat closer to each other by the year 2000. The Table also indicates that the projected price increases are uneven, being initially lower than the long term average. Since energy prices for the next few years are determined by the National Energy Policy independently of inflation, a possible decline in inflation would cause an increase in the real prices of energy projected for 1987 in Exhibit B-1. On the other hand, temporarily dropping world energy prices might have the opposite effect; the two impacts could compensate each other, and still make the figures in Exhibit B-1 a valid basis for projections.

Electricity

The price of electricity per gigajoule is substantially higher than the price of natural gas. It must be considered, however, that if conventional gas furnaces are used, assuming an efficiency of 62%, one gigajoule of electricity produces approximately 61% more heat in a home than one gigajoule of natural gas. Thus, in 1982 electricity did not cost much more than the equivalent natural gas in Eastern Canada (15% more in Ontario, 7% more in Quebec). It cost substantially more in Western Canada, due to the low price of gas. However, by 1987 electricity is projected to cost much more than natural gas everywhere, due primarily to the fact that in most provinces all the low-cost sources of power have already been developed and, therefore, the generation mix must include successively more costly sources. Nevertheless, the EMR projections for 1987, shown in Exhibit B-1, appear to be rather high and a steady escalation of 2.0% per annum over and above inflation may be more appropriate for electric energy, similarly to natural gas. This assumption would approximate the projections for the year 2000 quite well. One exception is Alberta, where real electricity rates are not projected to increase significantly, due to provincial policies which provide low-priced natural gas to the power utilities.

Oil

Exhibit B-1 shows that oil is the most costly form of heating energy (considering 65% furnace efficiencies), with the exception of Nova Scotia where the price of electricity is about the same as the price of oil. Oil furnaces in new houses are therefore extremely limited. According to Federal policies, the number of Canadians whose area is not serviced by natural gas should decline to a small percentage of the total population after New Brunswick and Nova Scotia have been supplied with natural gas, either through the proposed extension of the Trans-Canada pipeline (TQ&M) or from new sources at Sable Island.

Although it was originally projected that natural gas would reach the Maritime Provinces by 1987, it is now more likely that natural gas will not be available to individual homes until the 1990's.

GENERAL ASSUMPTIONS - PRIVATE PERSPECTIVE

Energy Price Escalation

In view of the data above, a single escalation rate was used in the study for all energy prices: 2.0% in real terms, or approximately 2 percentage points in excess of general inflation. Considering the uncertainties inherent in the EMR projections above, any assumption that would include more than one significant digit would imply an unrealistic forecasting reliability.

The most significant discrepancies between the results of this assumption and the data in Exhibit B-1, as far as the long term is concerned, would be in the projections for Western Canada. An assumption of uniform escalation rates would over-estimate natural gas prices for 1987 and underestimate them for 2000. In the economic analysis of the entire period, however, the errors caused by the assumption of a constant escalation rate may be compensating. Another significant discrepancy would be in the projection of electricity prices in Alberta; however, these prices are so high in Alberta that any form of electric heating would not be economically feasible anyway, at least not in urban areas.

Interest Rates

As far as interest rates are concerned, a real interest rate of 5% was used to represent a typical rate for mortgage loans. This means, for example, that if inflation was sustained at 5%, the corresponding mortgage rate would be 10.25%. Although deviations from this rule have occurred in the past, the 5% spread between inflation and mortgage rates appears to be a reasonable mean figure in the long term.

For the cost of money considered by individuals who invest their own cash in housing features, a different figure was used. This figure was the interest income foregone by investing money in the energy saving measure instead of investing it in some other way. To represent such an alternative investment, ordinary savings accounts were not considered appropriate, since saving accounts are liquid investments with the added benefit of allowing instantaneous withdrawal when required. This advantage is worth a few percentage points in comparison with sunk investments that cannot be easily converted into cash. The equivalent of an investment in, say, home insulation is the lending of the equivalent amount of money to someone else in the form of a mortgage. Neither of these would be cashable, and mortgage interest rates would therefore represent a better proxy for expected rates of return on an owner's cash investments than savings accounts. However, in the case of interest received (instead of paid) the issue of income taxes must be considered.

Taxation

Most persons investing their money in anything but owner-occupied homes, pension or retirement funds would have to pay income tax on the interest earned. Assuming no change in the income tax law, this means that if long term inflation was, say, 5%, a person could invest his or her money in a mortgage earning an income of 10.25%. If a person's marginal tax rate was 30%, the after-tax return on the person's investment would be 7.1%: only about 2% above inflation.

There is a wide range of assumptions that might be used regarding inflation rates and people's marginal tax rates. For example, a person whose alternative investment would be a Registered Retirement Savings Plan, has a zero marginal tax rate. A tax rate of 30% is estimated to represent an average for those people who buy a home for cash.

To recognize the real rate of return earned by a cash investor, a rate of 2% was therefore used, as derived in the example above.

The relative merits of investing in one's own home vis-a-vis other kinds of investment are quite clear. Whereas the after-tax returns derived from investments in savings certificates or mortgages are very low (if not negative) in real terms, investments in physical plant such as energy-saving features may have significant after-tax returns. The reason for this situation, which may not be widely understood, is the fact that since heating expenses are paid with after-tax money the returns represented by energy savings are non-taxable. It is safe to say that as long as present Government taxation policies prevail, the most profitable low risk investments available to private individuals, other than limited investments in tax-free savings funds, are those investments in physical property that provide opportunities for tax-free capital gains or savings in operating expenses.

TIME HORIZONS AND EXPECTED RETURNS

Home buyers have a wide range of perspectives when they evaluate the financial matters associated with their purchase. In their evaluation, explicitly or implicitly, they consider a time horizon. They also consider an expected rate of return over that time period.

The categories of homebuyers (with flexible or limited budgets, or those who finance the purchase with a mortgage or with cash) are discussed under separate headings.

Flexible Budget - Mortgage Financing

The credit limit of persons in this category is high enough to allow them to select energy-saving options in addition to other options already selected for

their new home, and finance these options by applying for an increased mortgage loan.

It can be shown that the impact of general inflation can be eliminated if both the mortgage interest rate and the fuel price escalation rate is expressed in real terms, i.e., in terms of percentages over and above the general inflation rate.

As noted earlier, the real mortgage rate used in this study to "model" the decision-making process of a home buyer with the most rational approach was 5% and the real fuel escalation rate was 2% per annum.

There is a wide range of personal judgement that determines the time horizon that a prospective home buyer would use in deciding to invest in an energy-saving measure.

At the low end of the spectrum, a prospective home buyer would install such a measure if the operating cost saving in the first year was expected to be at least equal to the amount of mortgage interest the new owner would have to pay on the capital value of the energy-saving measure. If the mortgage interest was 10.25% on a 25-year mortgage, the annual payment on a $1,000 investment would be $112; with a 12.5% mortgage it would be approximately $132.

These are the amounts that a home buyer would want to save annually in energy bills; this means that the buyer would look for investment/saving ratios between 7.5 and 9.0. Such a buyer would ignore the greater savings in later years due to energy price escalations.

The investment/saving ratio is equal to the so-called simple payback period: i.e., a ratio of 9 means that the investment itself would be recovered in 9 years if interest and energy price escalation were both ignored.(1)

One may intuitively estimate that the lower bound of the investment/saving ratio that would induce prospective home buyers to invest in energy-saving measures may be about 5, i.e., the simple payback period would be about 5 years. This appears reasonable since people may regard such a period as more or less predictable.

To calculate the upper bound of the investment/saving ratio, the expected price escalation of energy must be considered. The person most positively disposed toward energy conservation would be satisfied with fuel cost savings in the first year that are below the mortgage interest payments, knowing that in subsequent years the savings will increase, while mortgage interest payments may not. Thus, the most savings-minded person, in the most extreme case, would not use nominal interest rates (such as 10.25% or 12.5%) but interest rates that are "real" in terms of energy price escalation. That person would also use a 25 year time horizon (same as the mortgage term). A 10.25% mortgage interest rate in real terms is 5% when "real" is defined terms of a 5% general inflation and it is 2.94% when "real" is defined in terms of energy price escalation (2). This is because:

$$1.0294 \times 1.02 \times 1.05 = 1.1025$$
$$\{1.071\}$$

---

(1) If they were not ignored, (i.e., repayment of interest was also expected), ratios of 7.5 to 9.0 would correspond to payback periods of 9 to 10 years.

(2) Assumed energy price escalation is 7.1%, i.e., 2% above general inflation.

In an inflation-less world the annual payment for a 2.94% 25-year mortgage would be about $57 for each $1,000 invested. Adding the effects of inflation this payment would increase annually at the assumed energy escalation rate (7.1% per annum) and would pay off the mortgage of $1000 in 25 years.

A first-year energy saving of $57 would therefore be found adequate; this represents an investment/saving ratio (simple payback period) of 17.5.

Similarly, a 12.5% mortgage with a 7.1% general inflation (i.e., 9.2% energy price escalation) would be equivalent to 3.08% in real terms when "real" is related to the energy price escalation. This is because:

$$1.0308 \times 1.02 \times \underbrace{1.07}_{\{1.092\}} = 1.125$$

The result would be very similar to the previous case: the investment/saving ratio in the first year would be about 17.5.

It can be concluded that consumers would find an investment/saving ratio reasonable if it was between 5.0 and 17.5. Most people would probably not go beyond a ratio of 10.0.

Flexible Budget - Cash Financing

Persons belonging to this group would be primarily those who have sold a previous home and have the cash to pay for a new one. As noted, investment of one's own cash in a home is one of the best investments since the "in kind" benefits consisting of the enjoyment of accommodation, are non-taxable. Similarly, income earned through operating cost savings resulting from incremental investments, is tax-free.

For the cash investor, the study used a real interest rate of 0 instead of the approximately 3.0% used for the users of mortgage loans, "real" being defined in terms of energy price escalation. The reason for choosing no interest for

this category of home buyers is the assumed 2% after-tax real interest income (in terms of general inflation) and the 2% real energy price escalation: the two exactly compensate each other.

It is important to note that the full cash financing may apply only to the energy saving measures. The "selling point" to the public would be the explanation of the true after-tax income they receive from their other investments and the comparison of that with the prospective savings they can achieve through lower energy bills.

With actual after-tax interest rates being cancelled by the expected fuel price escalation rates, home buyers may ignore both and base their decision on simple payback periods (investment/saving ratios), ranging for most people from 5 to 10 years.

Limited Budget - Mortgage Financing

Persons in this category have reached their credit limit and must, therefore, increase their downpayment for any incremental investment. It can be assumed that home buyers who have reached their credit limit for mortgage loans, i.e., the debt service ratio specified by the lending institutions, have also a set budget for their downpayment, which they do not intend or cannot exceed.

The task facing this category of home buyers is not one of primarily economic evaluation. Their task is to allocate their available resources among available optional features by trading off economic against non-economic benefits.

Limited Budget - Cash Financing

Home buyers in this category are usually those who sold their previous home and have a limited amount of cash available for the purchase of a new home. The same considerations apply to these as to the home buyers in the previous category.

THE PUBLIC PERSPECTIVE

Whereas the private perspective includes only benefits accruing to the home owner who puts up the investment, the public perspective also includes benefits accruing to the Canadian public at large. There are differences between the public and private perspectives in the assessment of energy savings for all three major fuels: natural gas, oil and electricity.

Natural Gas

In the case of natural gas, savings in consumption provide benefits not only to the home owner who generated the savings, but also the Canadian public at large. This is because each cubic metre of natural gas saved in a Canadian home can concurrently or eventually be sold to United States consumers for a higher price, due to the fact that Canadians pay a lower price for natural gas than the corresponding price in the United States.

The "Energy Supply/Demand Outlook" of the Department of Energy, Mines and Resources (June 1982) projects the selling prices of export gas. These projections reflect current Government policies and assume that these policies will be continued in the future. However, at the prices presently set by the Federal Government, natural gas exports are well below the volumes that could be exported under present quotas. This situation is unlikely to continue indefinitely and export prices are likely to be adjusted eventually to levels that will allow the planned volumes of gas to be sold. In order to export the additional amounts of natural gas made available by conservation measures in Canada, additional discounts may have to be applied to the export prices projected by the EMR forecasts. Consequently, we estimated the public benefits derived from natural gas savings by assuming export prices 15 percent below the prices shown in the EMR projections. With that assumption, the "shadow prices" of natural gas, as seen from the public perspective, are projected to exceed the actual consumer prices by the following amounts:

1982: 51%
1987: 25%
2000: 21%

The savings accruing to the Canadian public as the result of energy conservation would exceed the savings experienced by an individual home owner by the percentages above. These percentages were calculated on the basis of consumer prices in Ontario. Their meaning is that if a home owner in 1987 can save $200 in his/her gas bill as the result of a conservation measure, the Canadian public as a whole (including the home owner) would save $250. Thus, the national economy would be enriched by $50 in addition to the consumer's direct saving of $200.

Oil

Similarly to gas, oil has a "shadow price" if viewed from the public perspective. Every litre of oil saved reduces Canada's requirements for imported oil and its dependence on that oil. Due to the National Energy Policy, that assures Canadians of obtaining oil at a price significantly lower than the world price, the Federal Government subsidizes the imports of foreign oil and levies a corresponding Petroleum Compensation Charge on the sale of all oil products to finance the subsidy. High-cost Canadian oil from new sources is also sold at lower prices, with the difference made up through equalization. For that reason, every litre of oil saved will relieve the Federal Government of having to the pay subsidy on that oil, resulting in a saving to all Canadian consumers.

The reduction of the reliance on imported oil has further benefits, beyond those of reducing the Petroleum Compensation Charge. There is a reasonable probability that within the next two decades there might be a major disruption of oil supplies due to some political upheaval in the world. Such a disruption would be so costly to the economy that the Federal Government, in its

EXHIBIT B-2

RATIOS OF "PUBLIC PERSPECTIVE" ENERGY COSTS TO "PRIVATE PERSPECTIVE" COSTS

- AT CONSUMER LEVEL

	Cost Ratios		
	Gas	Oil	Electricity
B.C.	1.30	1.25	1.25
Alberta	1.40	1.25	1.25
Ontario	1.25	1.25	1.25
Quebec	1.25	1.25	1.25
Nova Scotia	1.20	1.25	1.25

Figures are rounded.

economic evaluations, is justified in putting a premium on the cost of foreign oil, over and above the actual prices paid. The amount of such a premium is, of course, extremely judgemental. Arbitrarily, 15% may be added to the price of imported crude oil to account for the "price of security". This can be regarded as a reasonable insurance premium that the Government may pay into energy saving projects for each unit of foreign oil purchased, to be recaptured when eventually a disruption occurs and the energy saving investment pays off in terms of diminished economic damage. An assumption of a 15% premium results in the following increases in the cost of heating oil at the consumer level if viewed from the public instead of the private perspective:

1982: 43%
1987: 26%
2000: 19%

These increases are based on consumer prices of heating oil in the Maritime Provinces, where most of the new houses still using oil for heating are being built.

In line with these considerations, "public perspective" costs may be considered in this study for both natural gas and oil which would exceed the "private perspective" costs by amounts that are equal to 25% of the Ontario consumer price for natural gas and 25% of the Nova Scotia consumer price for oil. The resulting ratios of public to private perspective costs used for the entire study period are shown in Exhibit B-2. While used for the entire period, the ratios in Exhibit B-2 were calculated on the basis of projected 1987 prices.

Electricity

The prices of electricity can also be viewed from the "public perspective" or the "private perspective".

Electric power utilities blend their rates to all residential consumers, regardless of the actual cost of generating incremental amounts of energy. When electric energy is saved it is usually the output of the highest cost production units that is being reduced.

The ratio of the cost of energy actually saved (produced by the most costly generating units) to the average cost of all energy produced varies by province and with time in the future. To calculate these ratios would not be a simple task and would not be within the scope of this study. To simplify the consideration of these "top to average" cost ratios it was assumed that the "public perspective" cost of electric energy saved in home heating (top production cost) exceeds the "private perspective" (average) cost by 25 percent and that the same ratio applies to "public perspective" and "private perspective" consumer prices. This would make electricity comparable to natural gas and oil in terms of the differences between the public and private perspectives.

Interest Rates

To complete the discussion of the "public perspective", an appropriate real interest rate had to be determined. The 5% real interest rate assumed for the private perspective in terms of mortgage loans is clearly too high for the representation of the cost of money to Government. Recognizing that medium term Federal Government bonds usually bear interest approximately 2 percentage points below mortgage rates, a real interest rate of 3% was assumed for representing the public perspective. A time horizon of 30 years may be used for that perspective and an energy-saving measure was considered to be economically feasible if the investment/saving ratio was less than determined by these parameters. A 3% real interest in terms of general inflation corresponds to a 1% real interest in terms of energy prices (which assumed to escalate at 2% above inflation). An annual energy saving of 3.9% of the capital cost would pay back the initial investment at an interest rate of 1% in 30

years. The investment/saving ratio would therefore be 1/0.039 = 25.6 However, since the Government views savings in energy costs to be 25% higher than seen by the consumer, the savings/investment ratio in terms of actual consumer prices would be 1.25 x 25.6 = 32.

"Social discount rates" in excess of Federal bond rates have been suggested for use in benefit/cost studies. We believe that the conservation of energy is such a high priority issue that the feasibility of energy-related projects should be examined in the most favourable light, i.e., using interest rates as low as possible.

Social perspective issues beyond those discussed above have not been addressed. The focus of this study was the examination of the attitudes of the public and of barriers to energy efficient housing, and not the conduct of a comprehensive economic study. For that reason such issues as, for example, the impacts of the installation of energy saving measures on employment, or on Canada's balance of payments have not been considered.

(Continued on next page)

SUMMARY OF PARAMETERS

The economic parameters that were used in the economic evalutions are summarized below.

	PRIVATE PERSPECTIVE		PUBLIC PERSPECTIVE
	Mortgage Financing	Cash Financing	
Real interest rate %,	5	2	3
Real fuel price escalation rate %,	2	2	2
Fuel price related "relative" interest rate* %,	2.9	0	1
Time Horizon (1) years	7(3)-25(4)	5-10	30
Investment/Saving Ratio(2)	5.0-17.5	5.0-10.0	32.0

The ratios of public perspective costs of all forms of heating energy to private perspective costs at the consumer level were shown in Exhibit B-2.

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(1) "Discounted" payback period, considering interest

(2) Simple payback period, ignoring interest

(3) Mortgage payment would equal 1/5th of investment if repayment of principle was over 7 to 8 years.

(4) Cost of energy saving measure implicit in total mortgage: extra mortgage payments compared with future (escalated) energy prices.

GOVERNMENT ASSISTANCE

As discussed earlier, the benefits accruing to the general public from energy saving measures in houses can be broadly approximated by assuming that the public benefits are equal to 25% of the savings accruing directly to the owners of the houses. These public benefits are additional to the home owner's savings and are thus worth $25 annually for every $100 saved by the house owner.

We have shown that Government, in its own perspective, might consider a 1% real interest rate for investments related to energy saving and a time horizon of 30 years. This would justify an initial investment of $645 for annual savings of $25. According to estimates made earlier in this report, very few people would invest more than $1500 in an energy saving measure for expected annual savings of $100. Thus, since in the case of a measure that is expected to save $100 per year of the home owner's money, government is justified to pay a maximum subsidy of $645, this amount would be equal to about 30 percent of the total funds required for the installation of the measure.

As the majority of people would not invest more than perhaps $1000 for expected annual savings of $100, a government subsidy of $430 (30 percent of the total investment) would be more common for each $100 expected to be saved by the home owner. This would be equivalent to an annual public cost of $16.60 as compared with a benefit of $25.00 which was assumed to accrue to the public for each $100 of private saving.

It should be noted that the government is only justified in subsidizing those measures that are <u>additional</u> to the "base case", ie., to installations that would be provided anyway in the house. For example, government should only be expected to pay 30% of the costs of any <u>incremental</u> insulation installed by the home owner, not 30% of the costs of <u>all</u> the insulation. Similar considerations would apply to the costs of improved efficiency vs. basic furnaces.

APPENDIX C

EVALUATION OF ECONOMIC FACTORS

APPENDIX C

EVALUATION OF ECONOMIC FACTORS

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APPENDIX C

EVALUATION OF ECONOMIC FACTORS

The home buyers' principal reason for having energy saving measures installed in their new homes is to save money in the medium and long term. If the expected savings in future energy bills appear to be attractive to the home buyers in relation to the extra investment they have to make, and if there are no negative factors of a non-economic nature, it is likely that the buyer of a new home will install one or more energy saving measures or buy a house with such measures already installed by the builder. However, if the energy cost savings derived from the measure are not perceived to be in the economic interest of the buyers, they will in most cases decide against the measures, regardless of the non-economic factors. The consumer survey showed no evidence that there are any significant factors other than financial that will cause people to invest in energy saving measures. Although there may be some people who would invest in visible energy saving features as a form of social expression, it is believed that these instances are rather exceptional.

The economic analysis presented below attempts to simulate a home buyer's evaluation process, which he or she may carry out in the same manner as described, or in a less formal way, but arriving at conclusions that are largely similar to those derived here. Since there are few, if any, non-economic factors that would induce a home buyer to install an obviously uneconomical measure, such measures have a small likelihood of success.

The background of the economic analysis has been presented in Appendix B. That Appendix examined the approach that typical home buyers with an ability to carry out the appropriate financial analysis would take to decide whether a particular energy saving measure was economical from their point of view. It was shown how this approach would vary depending on the method of financing and the financial position of the home buyer. Appendix B also explored the

government's point of view, which considers social costs and benefits as well as the financial costs of energy.

The results of the economic analysis, carried out both from the consumer's and the government's point of view, are presented on the next pages. The planning parameters, i.e., the capital costs of the energy saving measures, the amounts of energy they save and the cost of energy have been thoroughly researched and are described. They are consistent with the data base of the CMHC-2 financial evaluation model. The evaluation covers a range of energy saving measures, including those that are widely known and used as well as some measures that are relatively new in the marketplace or are still at the pilot installation stage. Some measures which, according to preliminary calculations, are uneconomical under all Canadian conditions at the present time, were not included in the analysis. Other exclusions were made during the analysis, as explained below.

OBJECTIVES OF THE ANALYSIS

The first objective of the economic analysis was to determine the savings that buyers of new homes can expect to actually achieve if they invest in energy saving measures.

The second objective was to determine the additional savings in social costs that can be achieved through investment in the measures, representing the government's point of view.

CRITERIA FOR ECONOMIC FEASIBILITY

Three sets of criteria were defined for the determination of economic feasibility. These criteria represented the points of view of:

- the home buyers who finance the investment in the energy saving measure from their own funds,

- the home buyers who finance the energy saving measure through an increased mortgage loan,

- Government.

The economic parameters used in the evaluation are summarized in Exhibit C-1. A detailed discussion of these parameters was provided in Appendix B.

In the economic analysis, a real annual mortgage interest rate of 5% was assumed. This means that with an annual inflation rate of 5% the actual mortgage rate would be 10.25% (1.05 x 1.05 = 1.1025). The corresponding real government bond rate was assumed to be 3%: this was assumed to represent the cost of money to Government as well as the implied social discount rate (applicable to such "most desirable" objectives as energy saving). Energy prices were assumed to increase at a real escalation rate of 2% (i.e., with a 5% inflation rate, fuel prices would escalate at an annual rate that is slightly above 7%). The expected after-tax rate of return on the investment of private funds was assumed to be 2% in real terms. This is achieved, for example, when the annual inflation rate is 5% while the average before-tax investment income is 10.25% and the marginal tax rate of the investor is 30%. This means an after-tax income of 7.1% which is approximately 2% in real terms.

Time Horizons

It was assumed that many home buyers who invest their own savings in energy saving measures, would want to see their investment recovered in 5 years. Other people may have longer time horizons and may attach a greater importance to minimizing the carrying costs of their house in their old age rather than using their money for more short-term purposes. It is likely that even those people would like to see the investment paid back in 10 years.

EXHIBIT C-1

ECONOMIC ASSUMPTIONS

• REAL ANNUAL MORTGAGE INTEREST RATE:	5%
• REAL ANNUAL FUEL PRICE ESCALATION:	2%
• REAL GOVERNMENT INTEREST RATE:	3%
• REAL AFTER-TAX OPPORTUNITY COST OF PRIVATE CAPITAL:	2%*

PAYBACK HORIZONS

• SELF FINANCING:	5-10 YEARS
• MORTGAGE FINANCING**	5-25 YEARS
• GOVERNMENT FINANCING:	30 YEARS

GOVERNMENT CONSIDERS SOCIAL COST OF ENERGY AS 25% ABOVE CONSUMER PRICE

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* E.G.: - 10.25% INTEREST INCOME
- AT 30% MARGINAL TAX RATE AFTER-TAX INCOME IS 7.1%
- AT 5% INFLATION REAL INCOME IS 2%

** THIS FINANCING METHOD CAN ALSO BE ASSUMED IN THE CASE OF HOMES BUILT FOR RENT, IN WHICH CASE THE RETURN ON THE OWNER'S INVESTMENT IS IN THE FORM OF THE HIGHER RENT THAT CAN BE CHARGED FOR AN ENERGY-EFFICIENT HOUSE OR APARTMENT.

Home buyers whose line of credit allows them to add energy saving measures to their investment in the house, may, as an upper limit, use the time horizon of their total mortgage, which is typically 25 years.

This is a very long time horizon, especially when a financial payback of the investment requires the continuation of the levels of inflation reflected in the mortgage interest rate. A simpler view, more likely to be taken by most people, is a comparison between the first year's energy saving and the extra mortgage payment attributable to the investment in the energy saving measure. This means that people would not spend more on the measure than 7 to 9 times the first year's saving, which are typical ratios between borrowed principal and annual mortgage payments today.

It can thus be concluded that the time horizon of home buyers is in the range of 5 to 25 years with a more likely range of 5 to 10 years.

To represent the government's point of view, we assumed a somewhat longer time horizon: 30 years. To represent the social cost component of energy savings we assumed that Government would consider energy prices 25 percent above the actual in their benefits/cost calculations. This issue has been discussed in more detail in Appendix B.

Minimum First Year Payback

The maximum investment/saving ratios that would be acceptable to the consumer or Government under the assumptions above are shown below. If the investment in an energy saving measure were to be higher than the product obtained by multiplying the net savings in first-year energy costs (plus any extra maintenance costs) with the ratios below, the measure would probably be considered uneconomical by most consumers.

	Maximum Ratio
Home buyer with 5 year horizon:	5.0
Home buyer with 25 year horizon:	17.5
Most likely range:	5.0-17.5
Government:	32.0

The criteria above would have to be met by the measure as a prerequisite for being acceptable to the decisionmaker. As addressed elsewhere in the study, several other factors will also contribute to the decision of the home buyer; the importance of these factors diminishes, however, if the economic criteria were not met.

ENERGY SAVING MEASURES EVALUATED

The energy saving measures that were evaluated are listed in Exhibit C-2. A few comments on the measures are made below.

Improved air tightness without the installation of at least an exhaust fan has not been evaluated since a home with high levels of airtightness needs some form of ventilation at certain times (in addition to natural leakage) in order to ensure adequate air quality and prevent potential structural damage. The exhaust fan that can be activated by a device that senses humidity or simply by the occupants. Although at those times when the fan is operating, the heat loss of the house may be the same as the heat loss of a house without improved air tightness, the energy saving occurs at those times when the air quality is adequate and the fan does not have to operate.

Alternatives to the exhaust fan are: an air-to-air heat exchanger or a heat pump/heat recovery system. Both measures represent state of the art technology, but whereas heat exchangers are commercially available, heat pump/heat recovery systems are still at a pilot installation stage.

EXHIBIT C-2

MEASURES EVALUATED

1. INSULATION
2. IMPROVED EFFICIENCY FURNACES
3. SUPER EFFICIENT FURNACES
4. HEAT PUMPS
5. AIR TIGHTNESS WITH EXHAUST

Omissions from Evaluation

Two measures were excluded from the detailed economic evaluations because their economic feasibility is obvious and does not need analysis. They represent a very small investment and can achieve significant savings (broadly 10% of the energy bill with each measure). The two measures are:

- passive solar layouts
- programmable (nighttime setback) thermostats.

Three measures were omitted because preliminary evaluations showed that the annual savings are trivially low and, therefore, people cannot be expected to consider them when their mind is focused on the very large amounts of money associated with the purchse of a house. One of these measures is movable window insulation, which may produce annual energy cost savings in the order of $10-$20 for an installation cost in excess of $1,000. The two other measures in this category are: added water heater insulating jackets and fluorescent lighting. A typical home owner would save less than $10 per year with either of these measures.

METHOD OF EVALUATION

The steps applied in the economic evaluation are summarized in Exhibit C-3.

After the list of measures was defined, each measure was evaluated individually. The annual energy savings in dollars, less any incremental maintenance costs, were calculated and plotted against the initial capital cost of the measures. These and all subsequent calculations were carried out with the help of the CMHC-2 model.

Following the individual evaluations, groups of measures were selected. Judgment, based on the results of the individual evaluations, was used to define

EXHIBIT C-3

PROCEDURE FOR THE ECONOMIC ANALYSIS

1. SHOPPING LIST OF CONSERVATION MEASURES

2. COSTING OF EACH MEASURE ON A UNIT BASIS

3. ENERGY SAVINGS EVALUATION OF EACH MEASURE SEPARATELY ($ SAVING)

4. RANKING THE MEASURE IN ORDER OF COST/BENEFIT

5. DEVELOPING "MEASURES GROUPS" (OIL/GAS/ELECTRICITY)

6. COSTING THE GROUPS FOR HOUSE TYPES, FUEL TYPES AND CITIES

7. EVALUATION OF ENERGY PERFORMANCE (HOUSE/FUEL/CITY)

8. DEVELOPMENT OF "BEST CONSERVATION INVESTMENT" PROFILES (HOUSE/FUEL/CITY)

the groups. Although many combinations of measures are theoretically possible, a significant portion of these had to be eliminated as uneconomical, even though the individual measures were economical in themselves. This occurred when the introduction of one measure reduced the effectiveness of another measure, (i.e., the impacts of the measures were not additive).

The selected groupings of measures are shown in Exhibits C-4 and C-5. Homes in which the major source of energy was gas or oil were analyzed separately from homes in which the major source of energy was electricity.

Specification of Measures and Prices

The energy prices used in the analysis are shown in Exhibit C-6. The specification of the various measures and their capital costs were shown in Appendix A. Most of the measures include a series of sub-alternatives, represented by various "levels", of effectiveness and associated investment costs. As a rule, a higher "level" of a measure represents an option that costs more to install but saves more energy.

CASES STUDIED AND STUDY RESULTS

Exhibit C-7, shows five house types and five cities which were selected for analysis. Each city represents a typical region of Canada. The following house types were examined:

- Bungalow (100 sq. meters),
- 2 Storey Detached Home (125 sq. meters),
- Semi-detached Home (130 sq. meters),
- Row/Townhouse (102 sq. meters),
- Low-rise Apartment (84 sq. meters).

Ottawa was chosen as the "base case" for which all five house types were analyzed. In the other cities only two house types were examined.

EXHIBIT C-4

MEASURE GROUPS

GAS OR OIL

A	BASE CASE
B1	IMPROVED FURNACE
B3	SUPER EFFICIENT FURNACE
C1	INSULATION "1"
C2	INSULATION "2"
C3	INSULATION "3"
D1	INSULATION "1" + IMPROVED FURNACE
D3	INSULATION "1" + SUPER EFFICIENT FURNACE
E1	INSULATION "2" + IMPROVED FURNACE
E3	INSULATION "2" + SUPER EFFICIENT FURNACE
F1	INSULATION "3" + IMPROVED FURNACE
G1	SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1	SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-5

MEASURE GROUPS

ELECTRICITY

A BASE CASE
B2 HEAT PUMP

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D2 INSULATION "1" + HEAT PUMP
E2 INSULATION "2" + HEAT PUMP
F2 INSULATION "3" + HEAT PUMP

G2 SAME AS D2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H2 SAME AS E2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

I2 INSULATION "1" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
K2 INSULATION "2" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-6

FUEL PRICES FOR RESIDENTIAL SPACE HEATING

JANUARY 1983

	Fuel Oil[1] ($/L)	Electricity[2] ($/kwh)	Gas[3] ($/m³)
St. John's	.335	.044	-
Charlottetown	.336	.109	-
Halifax	.321	.055	-
Fredericton	.327	.035	-
Montreal	.326	.036	.2156
Ottawa	.326	.039	.2065
Toronto	.318	.039	.1838
Sudbury	.331	.040	.1878
Winnipeg	.319	.025	.1645
Regina	.316	.034	.1123
Edmonton	.313	.038	.1049
Vancouver	.318	.037	.1434
Prince George	.326	.037	.1170

(1) Latest "market" prices - Source: Imperial Oil.
(2) "Tail End" prices; where several utilities supply power in the same city, an arithmetic average "tail end" price is shown - Source: Local utilities.
(3) "Tail End" Prices are shown for cities in which block pricing is applicable - Source: Regional natural gas utilities.

Note:

To compare energy delivered to the homes the "equivalent gas price" can be calculated for oil and electricity (considering base case furnace efficiencies) by applying the following multipliers:

to fuel oil: 0.93
to electricity: 6.44

EXHIBIT C-7

CASES STUDIED

	HALIFAX	MONTREAL	OTTAWA	EDMONTON	VANCOUVER
BUNGALOW ($100\ m^2$)			GAS (59.9)		
2-STOREY DETACHED ($125\ m^2$)	OIL (51.5)	ELECTRICITY (58.1)	GAS ELECTRICITY (58.1)	GAS (70.0)	GAS (31.6)
SEMI-DETACHED ($130\ m^2$)			GAS (53.1)		
ROW/TOWNHOUSE ($102\ m^2$)	OIL (27.5)	ELECTRICITY (31.9)	GAS ELECTRICITY (32.2)	GAS (39.1)	GAS (15.6)
LOW-RISE APARTMENT ($84\ m^2$)			GAS (26.6)		

GJ/YEAR IN "BASE" CASE

In each region, the most economical and, therefore, most popular basic form of heating was assumed. This is oil in Halifax, electricity(1) in Montreal and natural gas elsewhere. However, to provide a cost-comparison between electric and gas heating, an electrically heated 2-story home and townhouse were examined, in addition to the corresponding gas heated homes in Ottawa.

The results of the analysis are presented graphically in Exhibits C-8.1 to C-8.15 at the end of the Appendix.

In the graphs the initial investment is shown on the horizontal axis. The saving in energy bills occurring in the first year after installation is shown on the vertical axis. The letters on the graph refer to the Measure Groups listed in Exhibits C-4 and C-5 and reproduced at the bottom of each graph.

The graphs can be used to test alternative decisions. The slope of the graphs represents the investment/saving ratios expressed in terms of the energy savings occurring in the first year after the investment. Where the slope is steep, the returns on the investment are high.

The three slopes shown on the top of the graphs, indicate the three criteria described earlier:

(1): The investment is 5 times the first-year saving, representing the point of view of a home buyer who invests his own funds and wants them returned in 5 years.

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(1) This used to be the lowest cost energy form in Montreal. Although gas might now be slightly cheaper in terms of annual energy bills, other advantages still appear to make electricity the favoured form in new homes.

(2): The investment is ten times the first-year saving. This represents an intermediate view between (1) and (3).

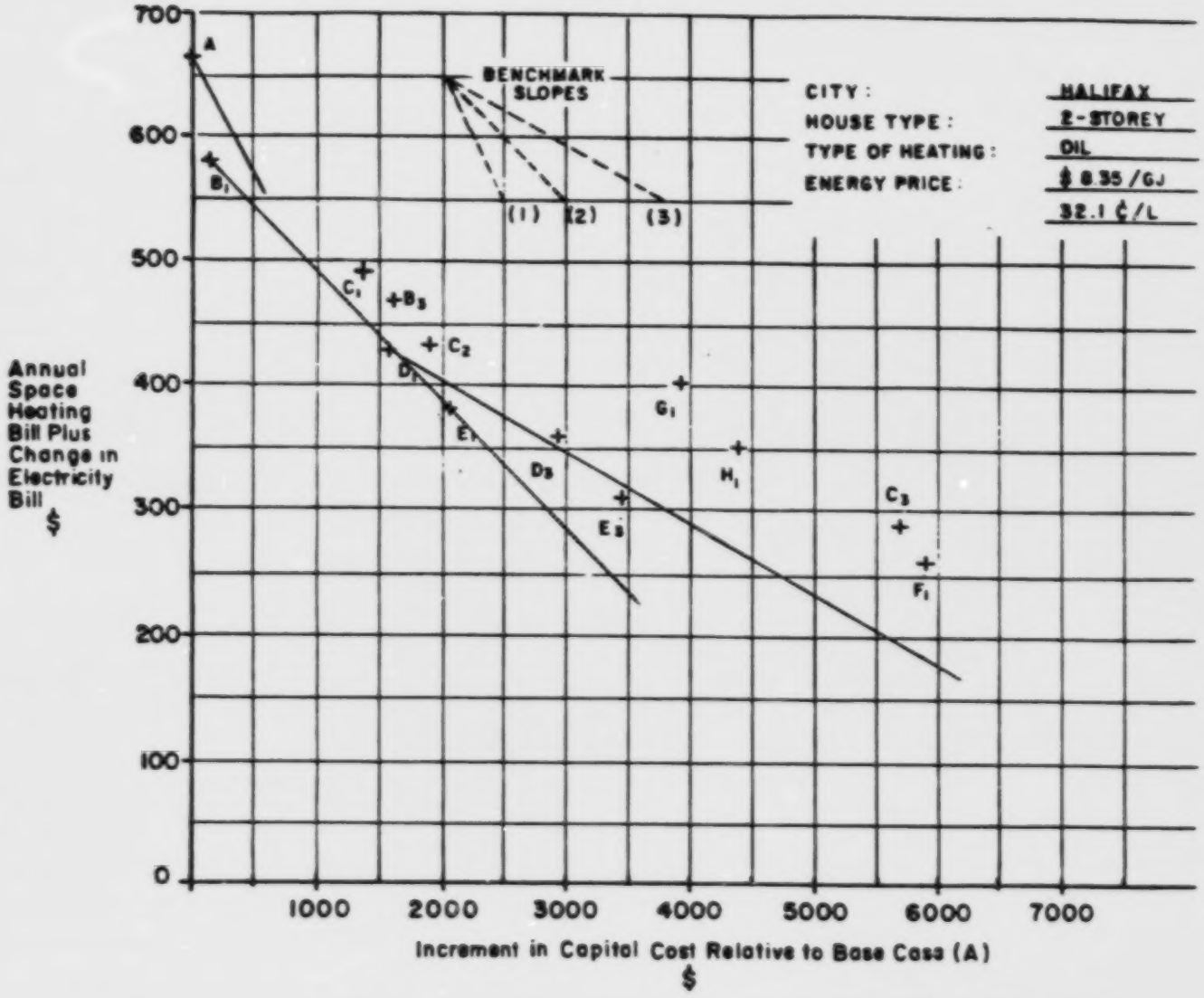
(3): The investment is 17.5 times the first-year saving, representing the point of view of a buyer who has a 25-year mortgage (which also covers the capital cost of the energy saving measure) and who takes the impact of inflation in energy costs into consideration.

The economic feasibility of the various measure groups can be tested by observing the slope between any two points that are compared. For example, in the Halifax 2-storey house case, shown in Exhibit C-8.1, Option B1 (Improved Furnace) is superior to Option A (Base Case) in everybody's view, since the slope of the line between A and B1 is steeper than Slope (1). The line between B1 and C1 ("Level 1" Insulation) is less steep than Slope (1), therefore a person who wants to save at least 1/5th of the original investment in the first year would not opt for C1. However, a person whose view corresponds to Slope (3), i.e., who does not want a greater saving than 1/17th of his investment in the first year, would find options D1, E1, D3 and E3 financially justified, since the steepness of the slope connecting these points is approximately equal to that of slope (3). To choose G1 (Heat Exchanger + "Level 1" Insulation) instead of E3 (Super Efficient Furnace + "Level 2" Insulation) in comparison with D1 (Improved Furnace + "Level 1" Insulation) would not be reasonable at the present prices of the measures, since E3 provides greater savings for less investment than G1.

A person with a middle-of-the road time horizon (Slope 2) would find it justified to choose Option D1 or E1 in comparison with B1 but none of the others. For example, the difference in investment between B1 (Improved Furnace) and C1 ("Level 1" Insulation) is greater than 10 times the difference in energy

EXHIBIT C-8.1 - REPRODUCED

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

cost savings and therefore, the choice of C1 over B1 would not seem justified. This is indicated by Slope (2) being steeper than the line between B1 and C1.

Similar analyses may be carried out for each location and each type of dwelling. The conclusions from the graphs are summarized below.

CONCLUSIONS

The conclusions below relate to the economic feasibility of the energy saving measures as viewed by the home buyer.

(1) In Vancouver and Edmonton, none of the measures would appear to be economical to a buyer of a row/townhouse or an apartment. The only measure that would appear to be economical to a buyer of a 2-storey house or a bungalow would be the improved furnace.

(2) In Toronto, Ottawa, Montreal and Halifax, the following measures would appear to be economical:

- "Level 1" or "Level 2" insulation,
- Improved Furnace, in itself or combined with "Level 1" or "Level 2" insulation,
- Heat Pump combined with "Level 1" or "Level 2" insulation, provided that the home buyer wanted to install air-conditioning anyway and, therefore, considered only the incremental cost of the heat pump over that of an air-conditioner.
- For 2-storey houses and bungalows only: Highly Efficient Furnace in itself or combined with "Level 1" or "Level 2" insulation.

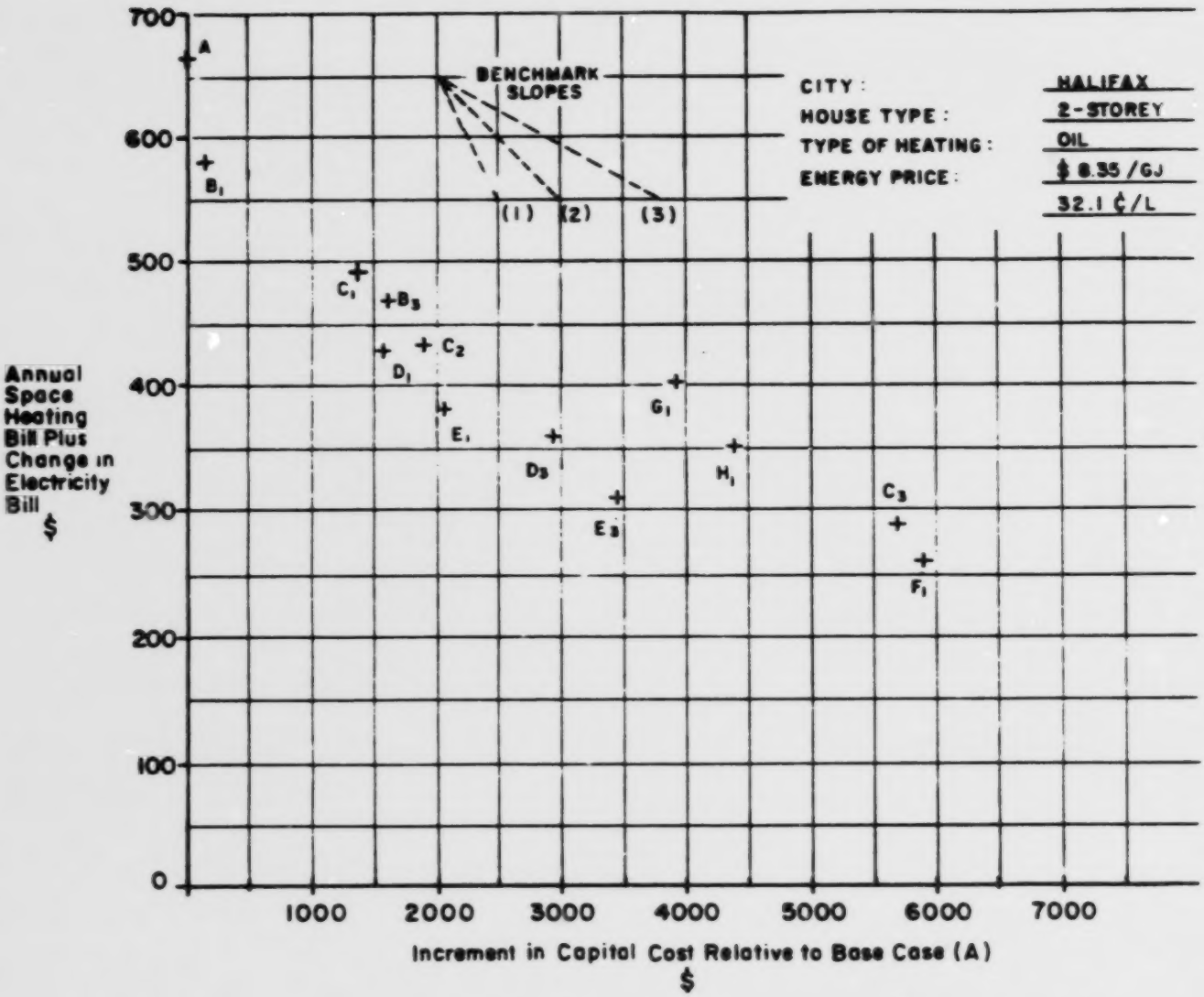
(3) Certain measures are made uneconomical by other measures, which provide greater savings for less investment. These superceded measures are:

- "Level 3" insulation,
- Heat exchangers.

Heat exchangers may become economical if their price dropped below today's levels.

EXHIBIT C-8.1

SAVINGS / INVESTMENT GRAPH



INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

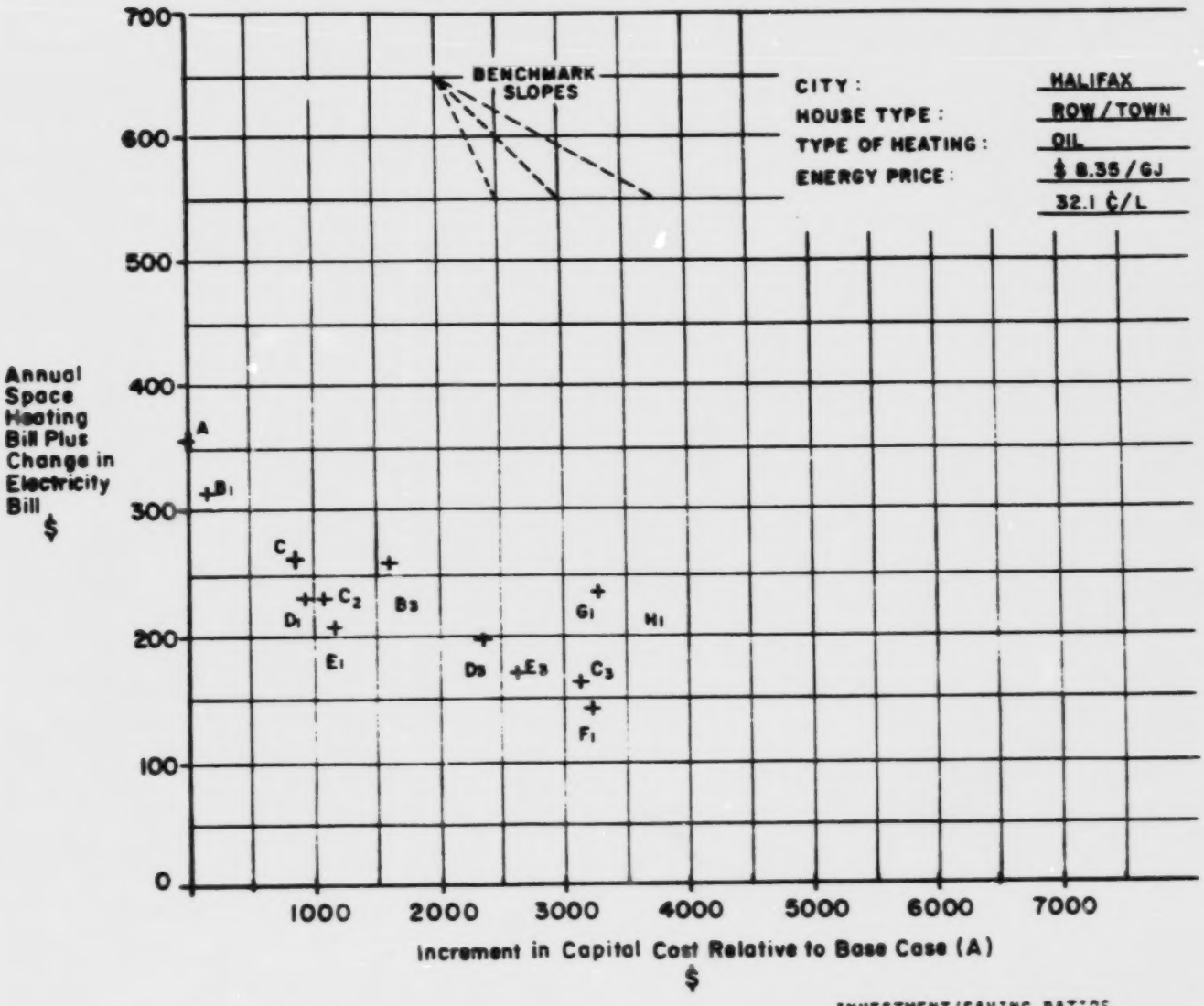
C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-8.2

SAVINGS / INVESTMENT GRAPH



INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

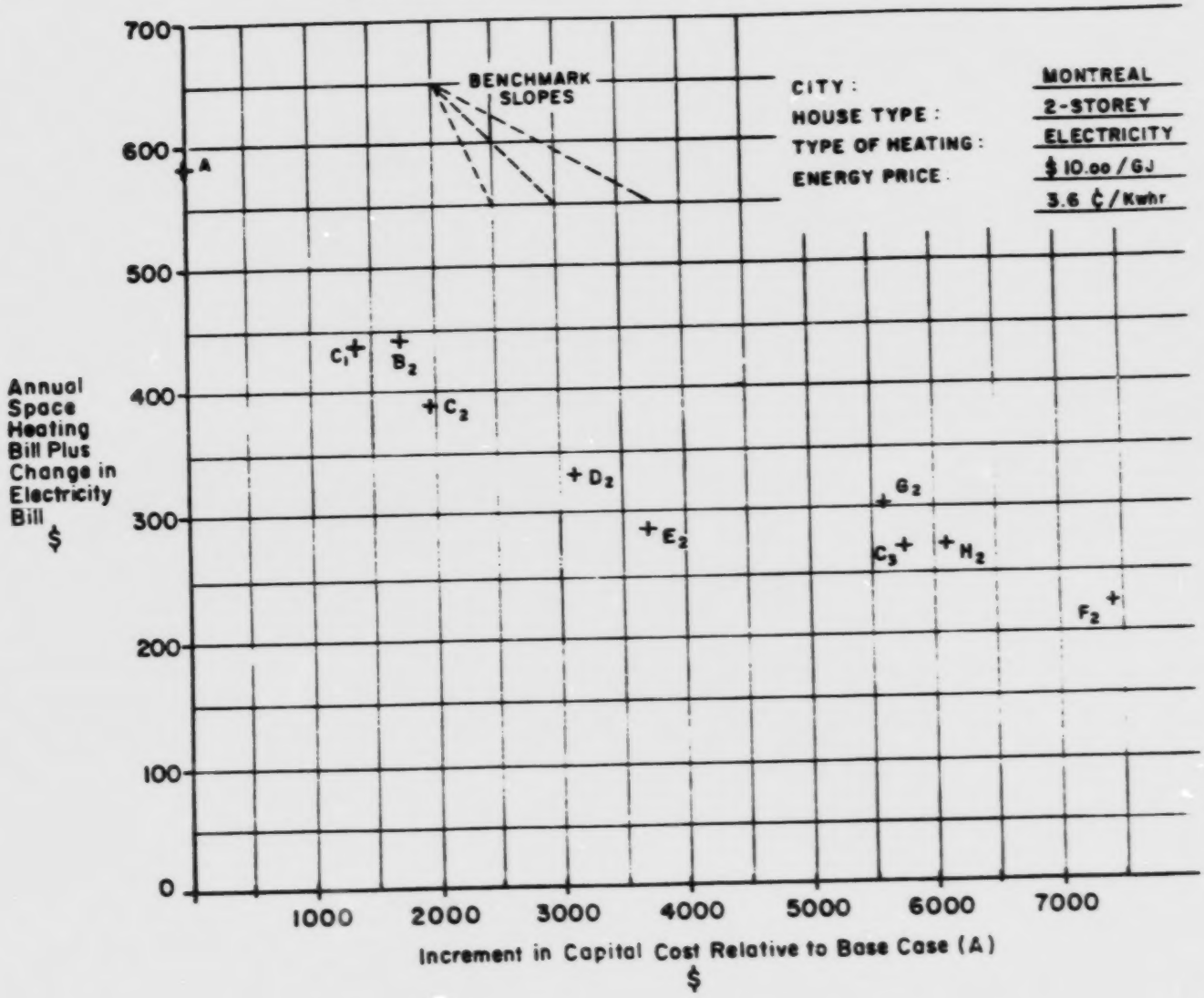
C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-8.3

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B2 HEAT PUMP *

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D2 INSULATION "1" + HEAT PUMP*
E2 INSULATION "2" + HEAT PUMP*
F2 INSULATION "3" + HEAT PUMP*

G2 SAME AS D2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H2 SAME AS E2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

I2 INSULATION "1" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
K2 INSULATION "2" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

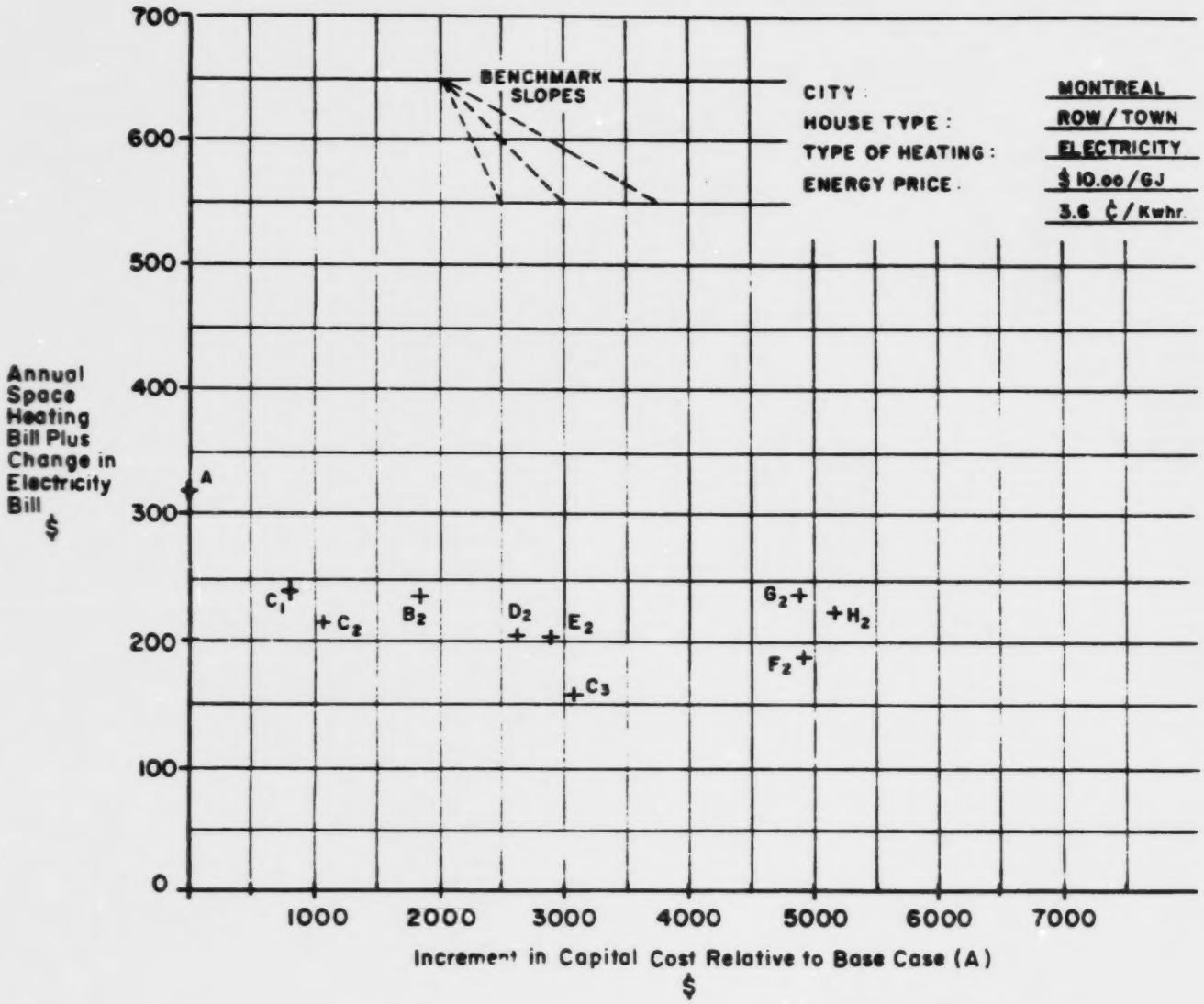
INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

* Excess capital costs over equivalent air conditione

EXHIBIT C-8.4

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B2 HEAT PUMP *

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D2 INSULATION "1" + HEAT PUMP *
E2 INSULATION "2" + HEAT PUMP *
F2 INSULATION "3" + HEAT PUMP *

G2 SAME AS D2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H2 SAME AS E2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

I2 INSULATION "1" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
K2 INSULATION "2" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

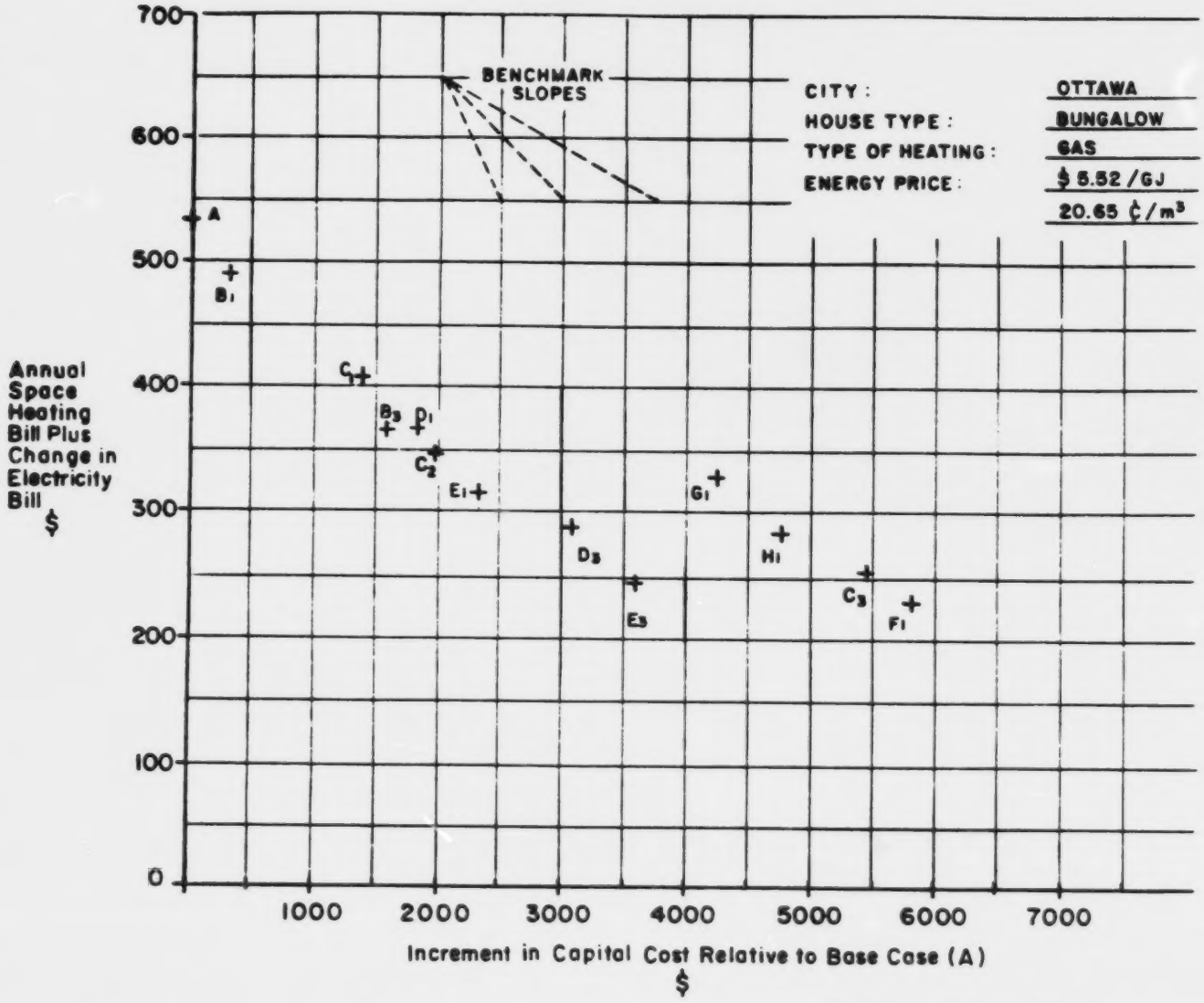
INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

* Excess capital costs over equivalent air conditioner

EXHIBIT C-8.5

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

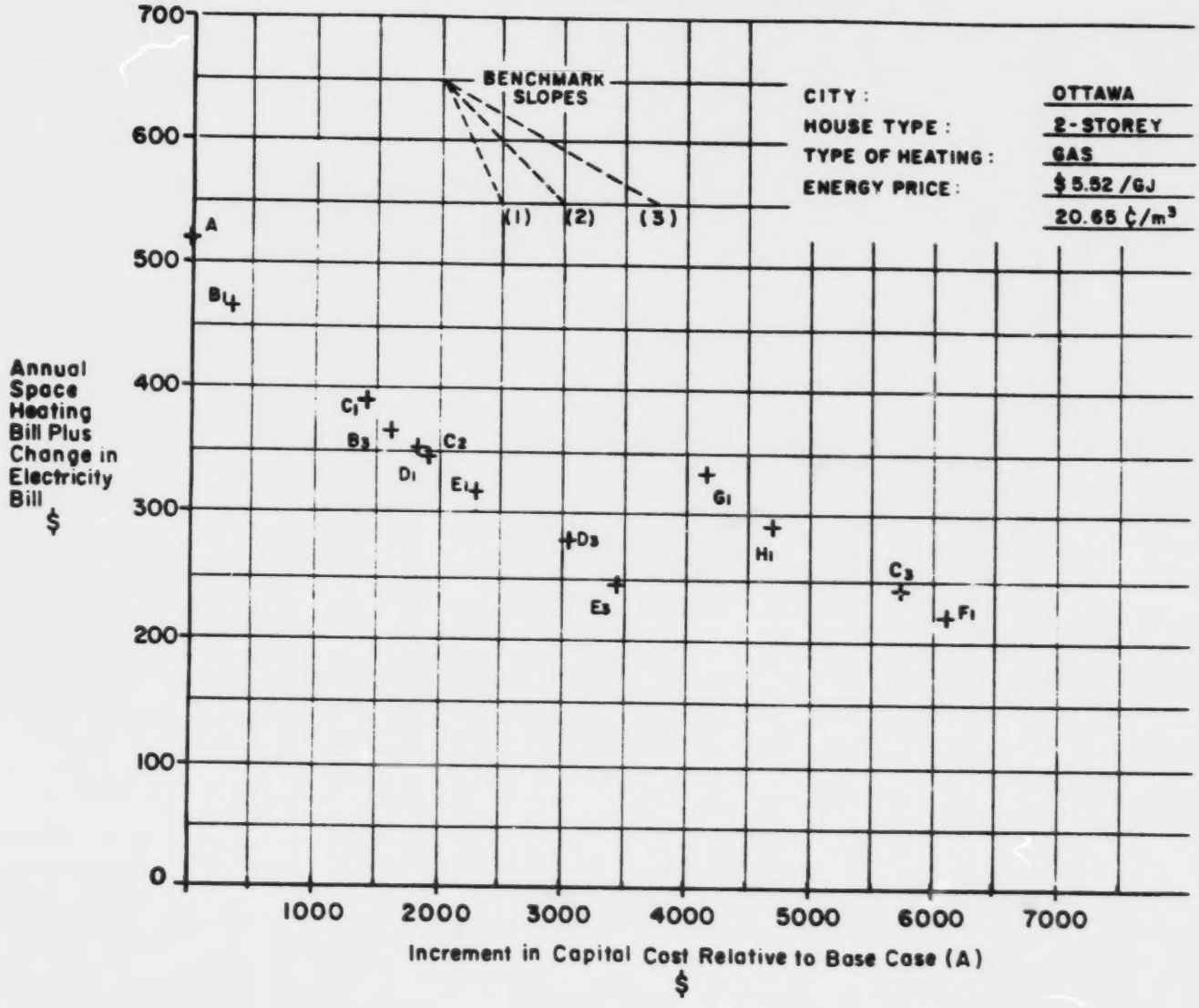
G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

EXHIBIT C-8.6

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

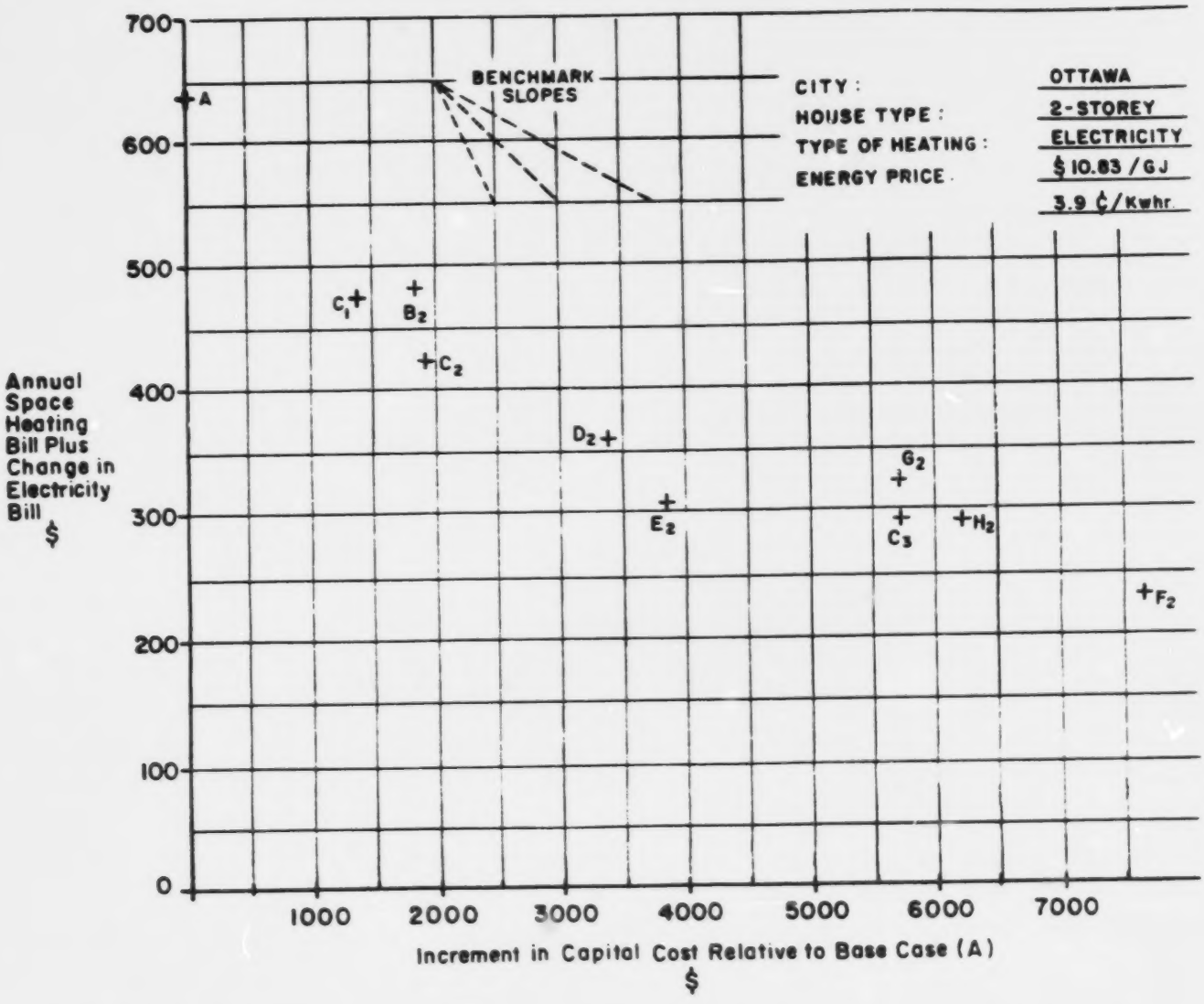
G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

EXHIBIT C-8.7

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B2 HEAT PUMP *

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D2 INSULATION "1" + HEAT PUMP *
E2 INSULATION "2" + HEAT PUMP *
F2 INSULATION "3" + HEAT PUMP *

G2 SAME AS D2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H2 SAME AS E2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

I2 INSULATION "1" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
K2 INSULATION "2" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

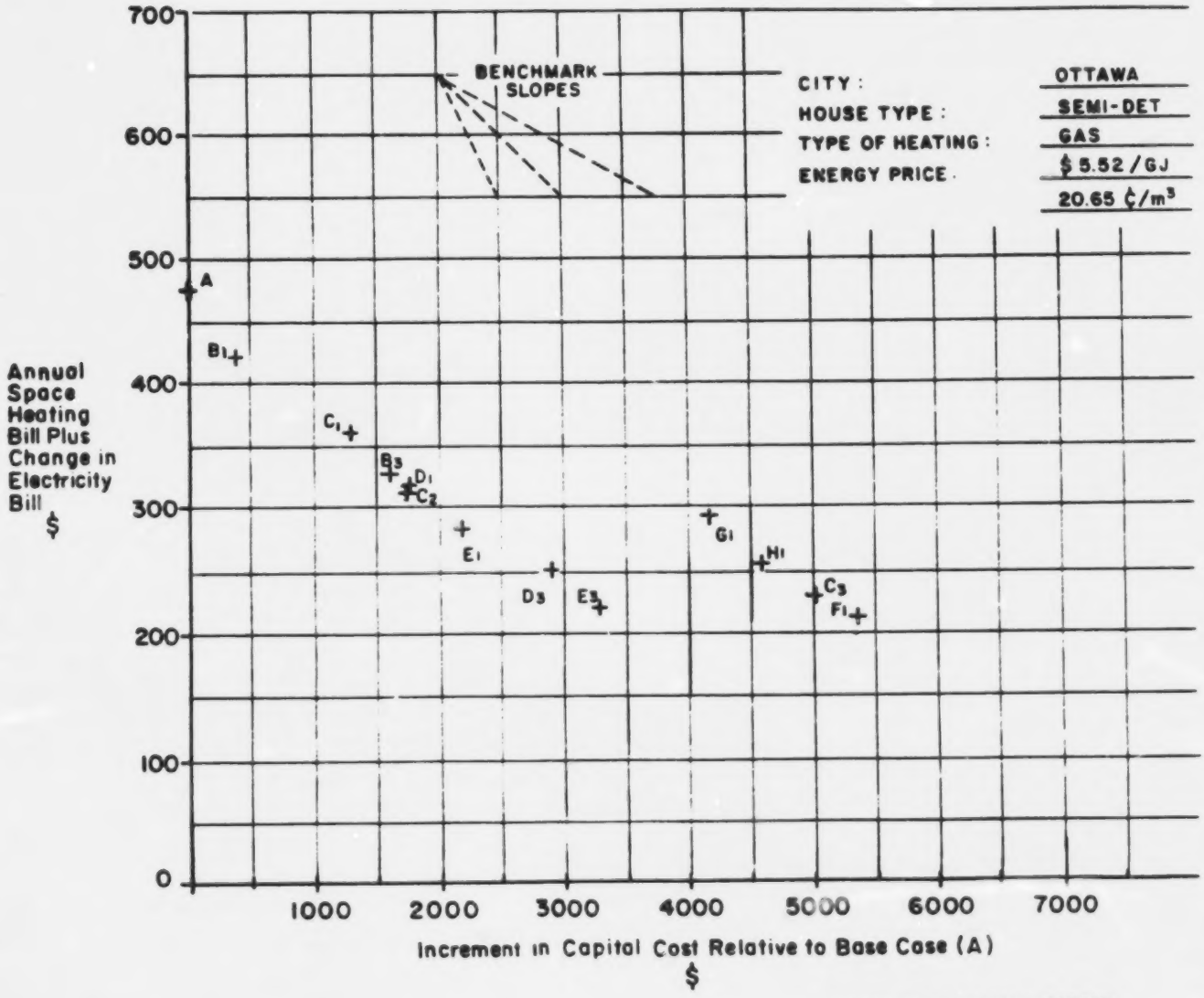
INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

* Excess capital costs over equivalent air conditioner

EXHIBIT C-8.8

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

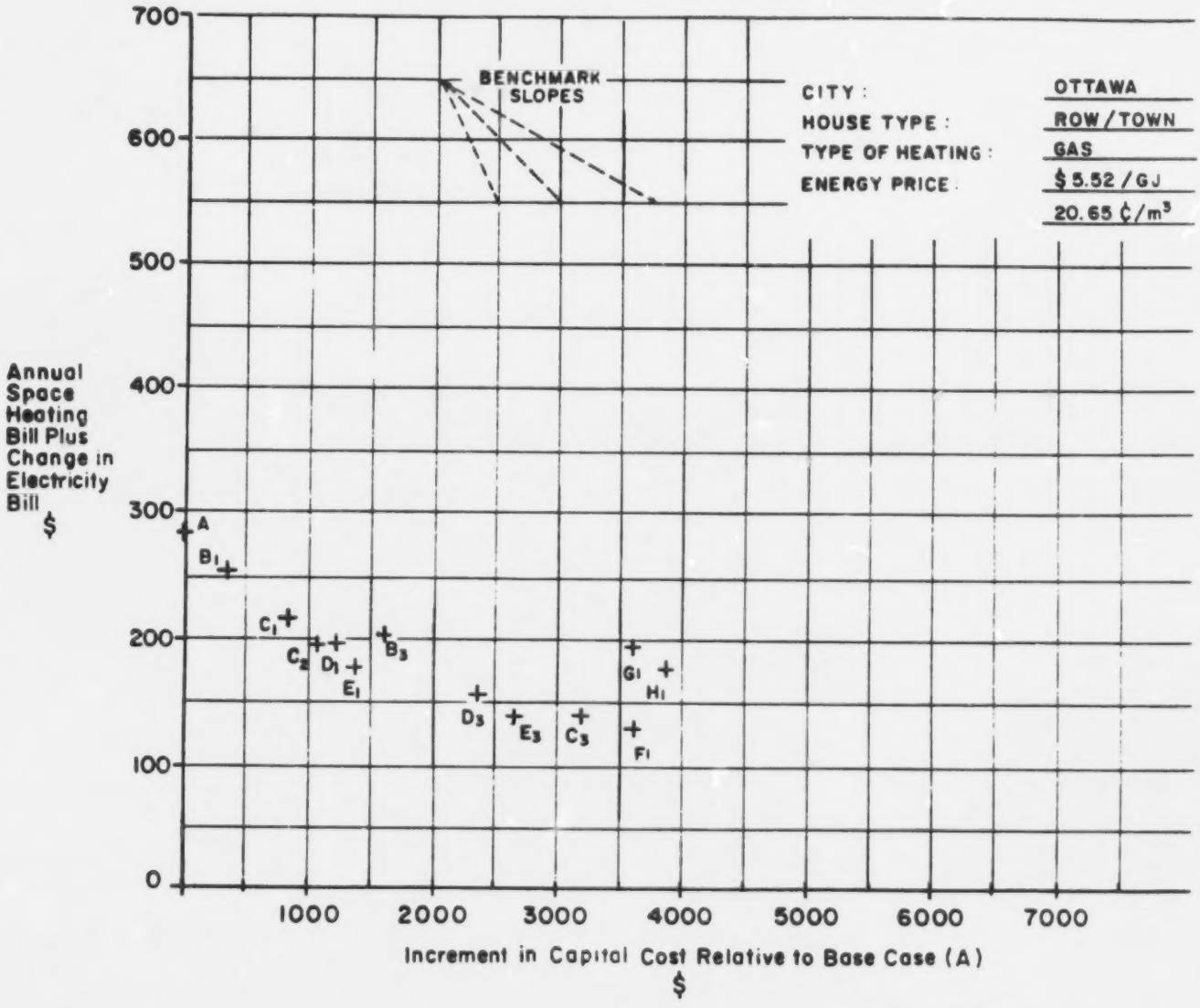
G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

EXHIBIT C-8.9

SAVINGS / INVESTMENT GRAPH



INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

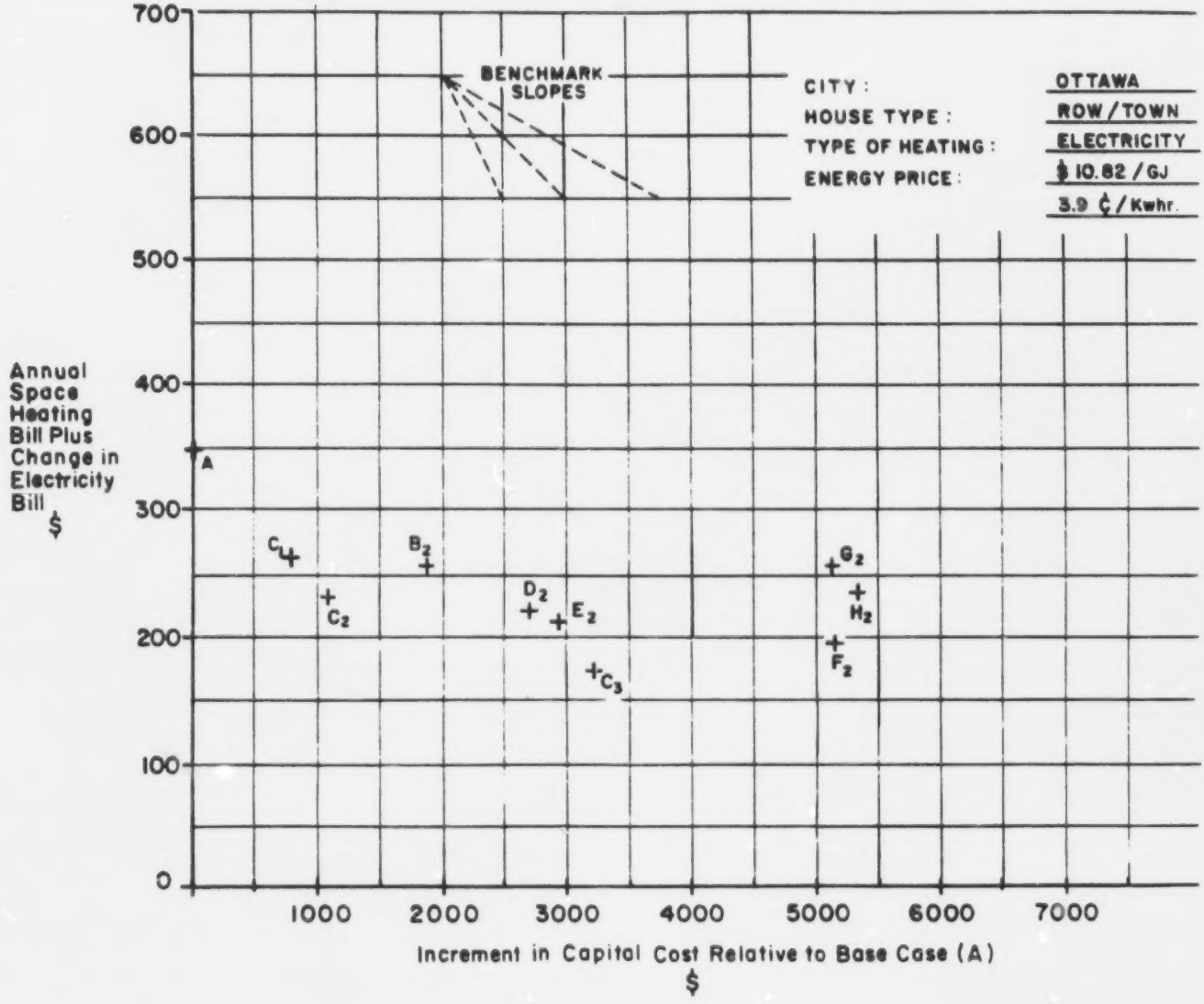
C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-8.10

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B2 HEAT PUMP *

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D2 INSULATION "1" + HEAT PUMP *
E2 INSULATION "2" + HEAT PUMP *
F2 INSULATION "3" + HEAT PUMP *

G2 SAME AS D2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H2 SAME AS E2 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

I2 INSULATION "1" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
K2 INSULATION "2" + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

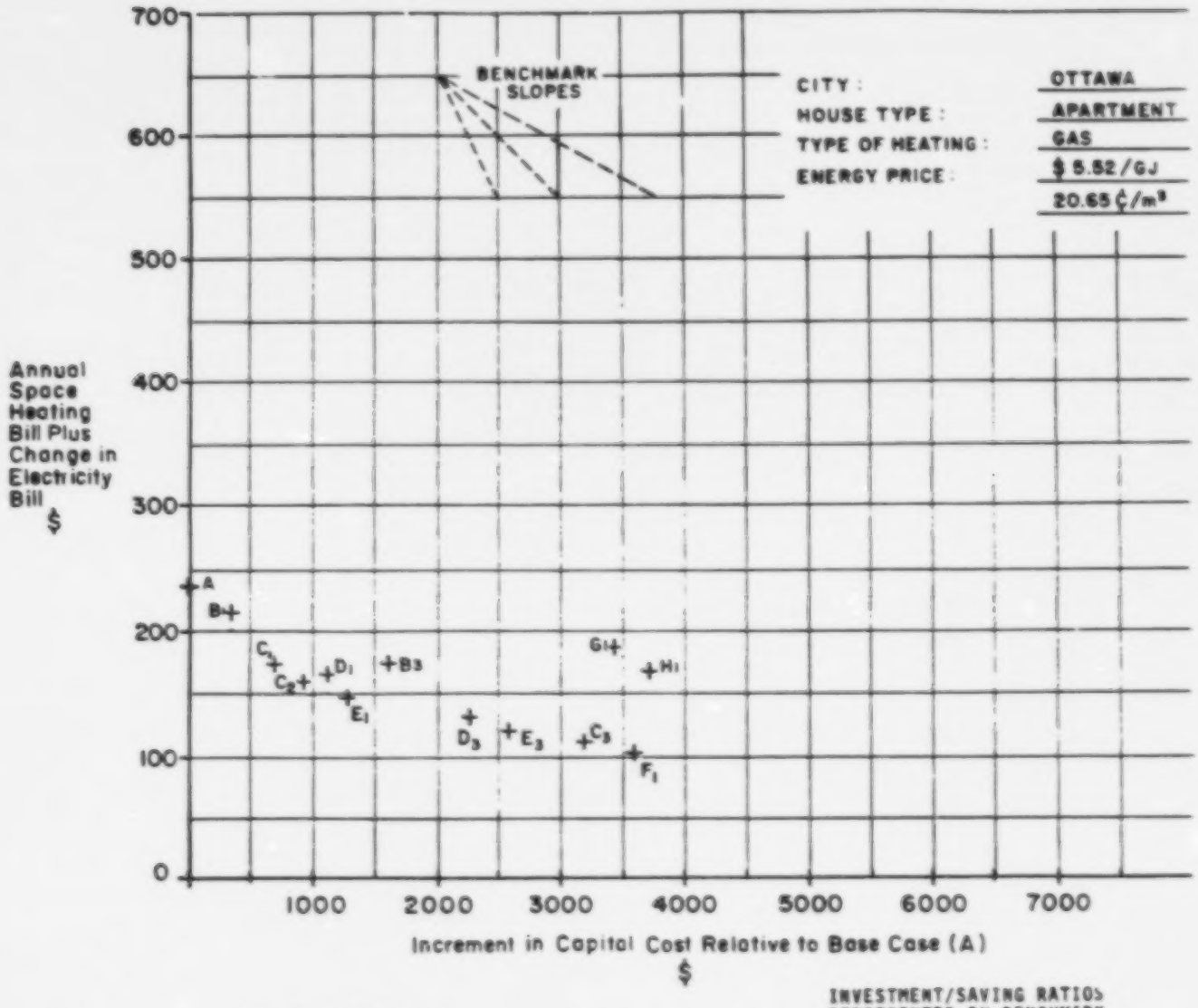
INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

* Excess capital costs over equivalent air conditioner

EXHIBIT C-8.11

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

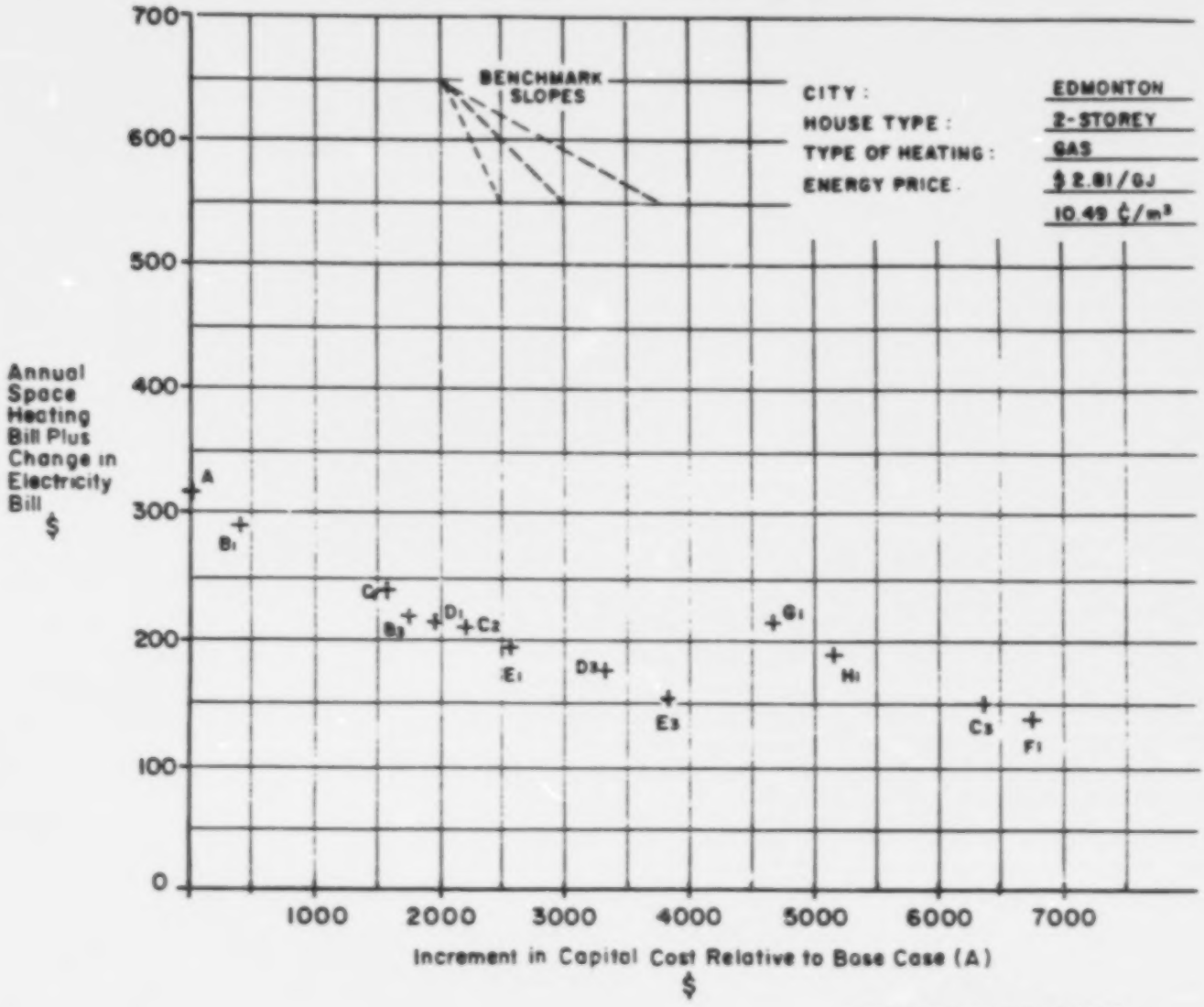
G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

EXHIBIT C-8.12

SAVINGS / INVESTMENT GRAPH



INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

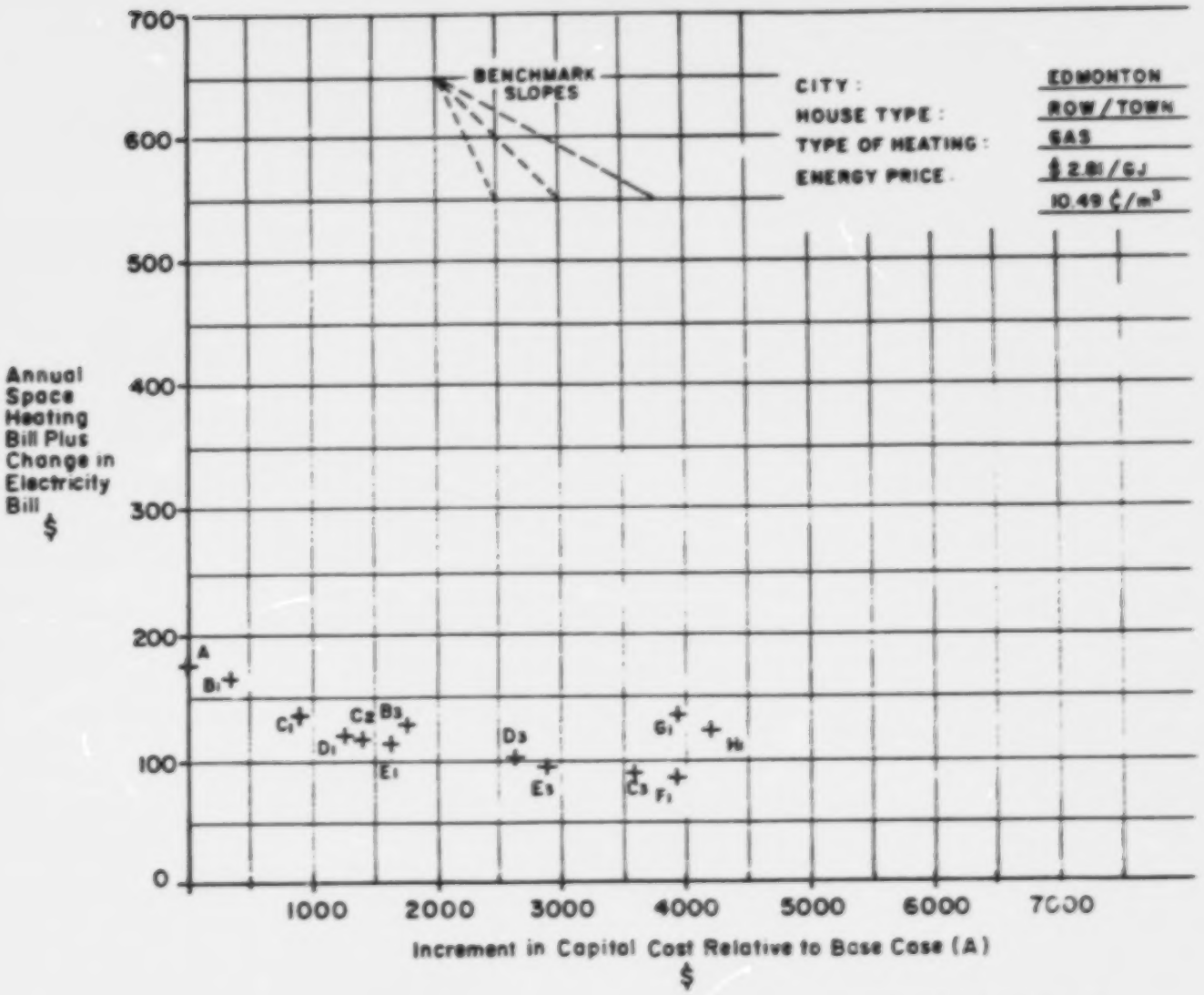
C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-8.13

SAVINGS / INVESTMENT GRAPH



A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

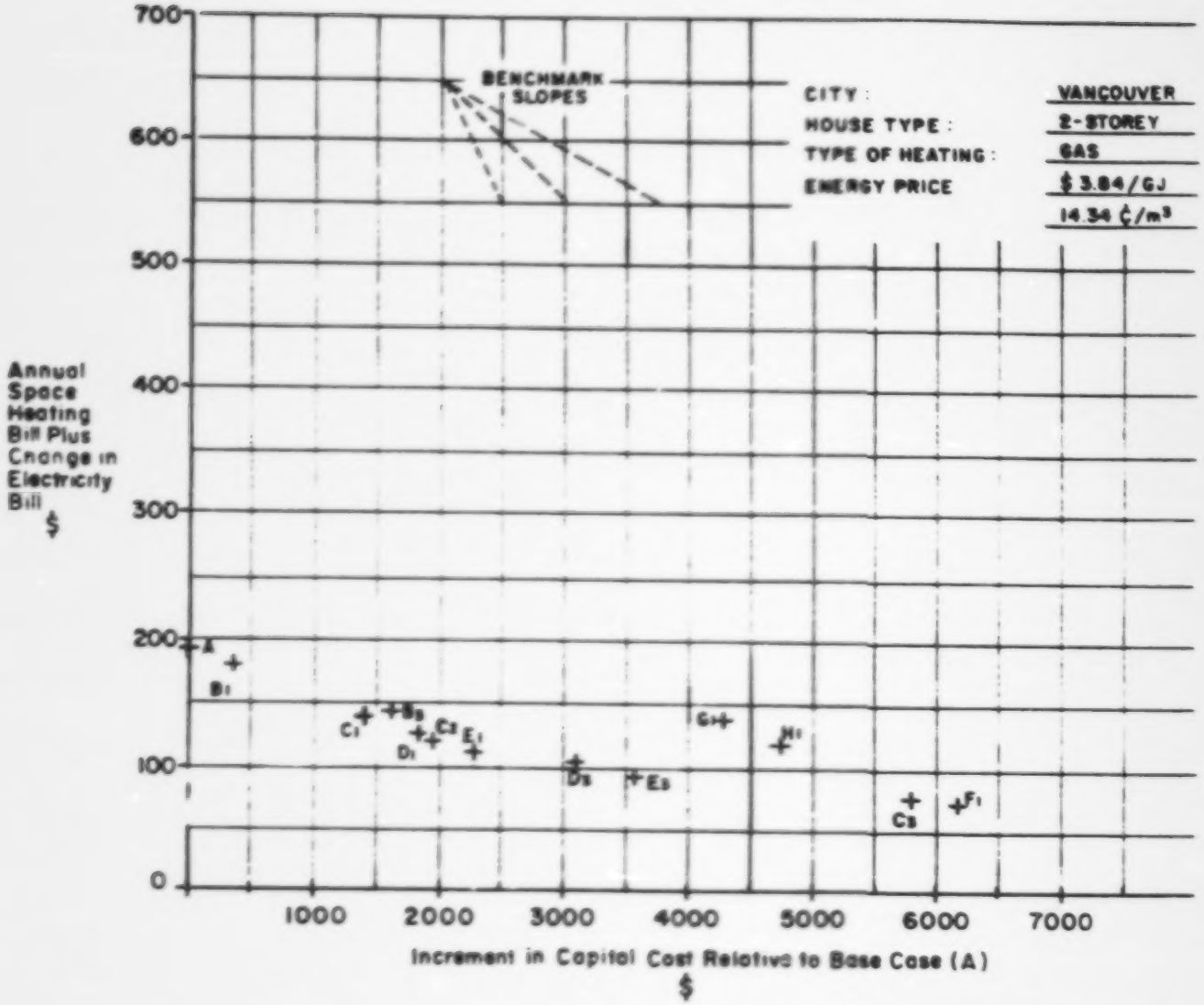
G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

EXHIBIT C-8.14

SAVINGS / INVESTMENT GRAPH



INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

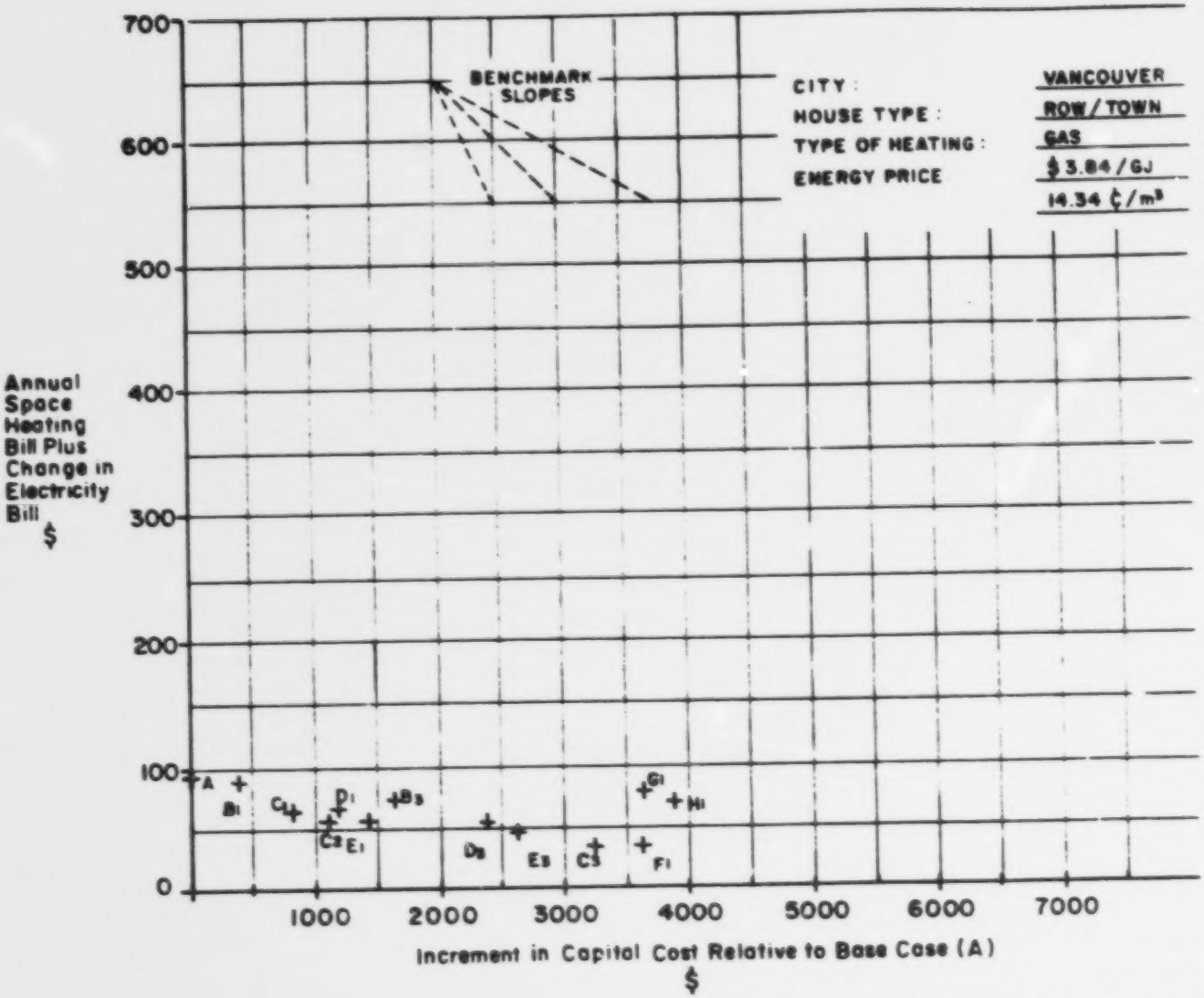
C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

EXHIBIT C-8.15

SAVINGS / INVESTMENT GRAPH



INVESTMENT/SAVING RATIOS REPRESENTED BY BENCHMARK SLOPES:

(1): 5.0 (SHORTEST TERM VIEW)
(2): 10.0 (MEDIUM TERM VIEW)
(3): 17.5 (LONGEST TERM VIEW)

A BASE CASE
B1 IMPROVED FURNACE
B3 SUPER EFFICIENT FURNACE

C1 INSULATION "1"
C2 INSULATION "2"
C3 INSULATION "3"

D1 INSULATION "1" + IMPROVED FURNACE
D3 INSULATION "1" + SUPER EFFICIENT FURNACE
E1 INSULATION "2" + IMPROVED FURNACE
E3 INSULATION "2" + SUPER EFFICIENT FURNACE
F1 INSULATION "3" + IMPROVED FURNACE

G1 SAME AS D1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)
H1 SAME AS E1 + HEAT EXCHANGER (WITH "LEVEL 2" AIRTIGHTNESS)

APPENDIX D

NON-ECONOMIC FACTORS

APPENDIX D

NON-ECONOMIC FACTORS

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APPENDIX D

NON-ECONOMIC FACTORS

DESCRIPTION OF THE FACTORS

The non-economic factors were examined to assess the extent to which they may enhance or delay the achievement of energy-efficient new housing, with particular attention being given to potential impediments and their real or perceived reasons. Initial factors were identified and the number of factors, as well as their definition and impact, were reassessed several times as information from literature reviews and surveys became available.

The investigations showed that some factors had no impact on the installation of energy saving features. They were, nevertheless, left in the list of factors for the sake of completeness.

Factors were divided into three groups:

- supply factors
- performance factors
- institutional factors.

These groups of factors broadly correspond to three target groups: builders, consumers, and government agencies.

The factors are described using a standard format, starting each factor on a new page.

A. SUPPLY FACTORS

1. POTENTIAL LACK OF BUILDER OR PRODUCT DESIGNER KNOW-HOW

Definition

The know-how of designers and builders is their working knowledge of technically feasible energy-saving measures for new homes.

Potential Impacts

The designers of houses do not appear to play a role in the incorporation of energy saving measures with the exception of the design of passive solar layouts. Product designers have a greater impact as this type of designer know-how is important for the development of reliable high technology measures such as condensing gas and other super efficient furnaces, heat pumps and heat exchangers.

Builder know-how is important for all the measures, as builders are the means by which a product is marketed to the public and installed.

Current Status

At present, the state-of-the-art in designing and building energy-saving measures which may not be widely available, resides with specialized consulting firms and such bodies as the National Research Council. Various government bodies and builders' associations disseminate this information. Several builders mentioned having attended CMHC seminars.

The builders' major source of information on currently available materials and equipment in the energy conservation field is the supplier. The supplier sends unsolicited pamphlets directly to the builder describing the product and

how to get it. The supplier advises the builder on the proper use of the product and deals with any problems which may occur with the installation of the product.

Geographical Aspects

Builder know-how was the most extensive in Ottawa. The only builder among those surveyed who installed heat exchangers was in Ottawa. This may indicate high consumer demand in Ottawa.

Montreal builders showed comparatively little interest or knowledge in energy conservation measures.

Future Trends

Heat exchangers will become better known and marketed more widely in Canada. Two small firms sell them: Alen, Drerup and White through The Air Changer Company, Toronto, distributed by Lennox, and Conservation Energy Systems, Saskatoon. Allen, Drerup and White have been selling heat exchangers for three years.

Hopefully, with increased volume, prices might decrease to the level at which significantly more consumers will find heat exchangers economical. Other manufacturers may also enter the market. As shown in the report, at present prices heat exchangers are not economical in average size houses and are assumed to be installed primarily in larger houses.

2. REPUTATION OF THE PRODUCT OR ITS SUPPLIERS WITH THE BUILDERS

Definition

The reputation of a measure is the builders' general opinion of the reliability, effectiveness and consumer appeal of an energy saving measure.

Potential Impacts

The introduction of a theoretically sound and appealing measure may be slowed or even halted, if the builder believed that he may have trouble with the installation, and/or maintenance of a measure.

Current Status

Based on the survey of builders, it appears that this factor is important only for the higher technology items such as heat pumps and heat exchangers. Several builders expressed the view that heat exchangers were not effective devices. Some builders did not know where to buy a "reliable" heat exchanger.

Geographical Aspects

None

Future Trends

Builders who are innovators or "early adopters" will be subject to the problems and risks associated with any product in its first stages of penetration in the marketplace. Through feedback from these builders, suppliers may improve their product, and eventually, the energy saving measure will become

widely known as "proven" technology. Consequently, this factor may simply be indicative of the stage of product penetration and will become less important in time.

3. POTENTIAL INEXPERIENCE OF THE TRADES

Definition

The inexperience of the trades is the lag in the ability of the construction trades to install energy saving measures to appropriate specifications at the expected cost.

Potential Impacts

This factor, if present, could adversely affect the economics of the energy saving measures in two ways:

a) incorrect installation which has to be subsequently corrected and results in higher labour and material costs,

b) incorrect installation which is not corrected and results in the measure not delivering energy savings up to its specifications.

Current Status

From our builder surveys we learned that the trades have gone through a learning process over the past few years, especially in the area of vapour barriers. They also reported that the trades learn how to install any measure by trial and error. Consequently cost effectiveness may sometimes leave something to be desired in the short-term. Several builders said that CMHC inspectors helped the trades learn how to install measures correctly.

More supervision than normal is required to ensure the proper installation of vapour barriers, as there are many ways to cut corners. Without supervision, the measure's energy saving effectiveness may be impaired due to poor instal-

lation methods. There are no special skills required to install a vapour barrier, however.

In the case of insulation, low cost-effectiveness can be more easily avoided. Many builders prefer to use 2x6 construction as this enables the quick installation of a high R-value. Insulating sheathing, which is awkward to install, is needed for a high R-value in 2x4 construction.

Although the effectiveness of any energy saving measure may be affected by improper installation, the builder survey showed that insufficient cost effectiveness of the trades has the greatest negative impact on vapour barriers.

Geographical Aspects

As labour costs vary across the country, it might be expected that the cost-effectiveness of the trades will have a correspondingly uneven impact on the installation of energy saving measures across the country. According to the builder survey fewer caulked vapour barriers are installed in Vancouver, Toronto and Calgary where labour costs are highest, than elsewhere. However, the more temperate climate in Vancouver and lower energy prices in Calgary may also explain this situation.

Future Trends

None.

4. LAGS IN SUPPLY OF HOMES WITH ENERGY-SAVING MEASURES

Definition

A lag in supply occurs when the consumer demand for a product is not met immediately.

Potential Impacts

This factor affects the time and the rate at which new houses with energy saving measures in the houses will penetrate the market. It could be theorized that even though the installation of energy-saving measures may be economically desirable, there may be few new homes available which are equipped with them.

Theoretically, the reasons for the lag could range from the need for municipal approvals, to lack of special materials or skilled labour, to poor response by the builder to demands in the market place.

Current Status

The industry can and currently does respond within a very short time to consumers' demands. This may be somewhat in contrast with the past when tight supply conditions in the housing market favoured the builder and, therefore, the response to the consumer might have been slower than today. As most houses today are built after they had been sold, there is no difficulty in incorporating the measures that the consumer demands.

Geographical Aspects

None.

Future Trends

None.

5. BUILDERS' MARKETING METHODS AND THE USE OF ENERGY SAVING AS A SELLING TOOL

Definition

Marketing methods are the steps in the process of selling a house. Energy saving may be used as a marketing tool through advertising the availability of various measures, providing information on them and/or including them on options lists.

Potential Impacts

If information about energy saving measures and their value was not made available by the builder or the real estate agent, this could act as an impediment to the demand for energy saving measures.

It could be theorized that it might sometimes be unattractive to the builder to have special energy saving measures incorporated in a standardized house since this may result in a longer waiting period, or in special charges. If this was so, it might serve as an impediment to the take-up of energy saving measures.

Current Status

Large Builders/Developers

A list of options is made available to the prospective buyer, the scope of which is determined by the price of the house. The items which are provided in the house as standard and those which are on the options list are determined by the builder by reviewing the demands of previous buyers and of the first few prospective buyers who come to the sales office, taking into consideration the price range of the house.

The cheaper the house, the fewer standard items are provided. In more expensive houses, energy saving measures are sometimes offered as standard. Improved efficiency furnaces and night setback thermostats are examples of measures which have been included as standard items.

In other cases, energy saving measures are being included on the options list, particularly on those of higher priced houses. Heat pumps, improved efficiency furnaces, extra insulation in attic, and heatilators are examples of energy-saving options offered.

Builders consider the options list as a means of anticipating the consumer's requests. Builders are willing to put anything on the list they thought would sell.

The role of real estate agents in providing information about energy saving measures seemed to be more limited than the role played by the builders. Their role is mostly in the re-sale of houses. A greater involvement of real estate agents in the issues of energy saving could lead to a better reflection of the energy performance of a house in its re-sale price and, therefore, could favourably influence the decision of a new home buyer regarding investment in an energy saving measure.

Small and/or Custom Builders

Small builders are flexible as they build fewer houses. Custom builders are willing to install any feature requested, because this is the nature of their business.

As one might expect, custom builders often prove to be innovators or "early adaptors" of new products; some larger builders are, however, also not far behind.

Geographical Aspects

None.

Future Trends

None.

B. PERFORMANCE FACTORS

6. PERCEIVED HEALTH HAZARDS

Definition

Perceived health hazards are breathing problems, headaches and visible signs, such as rashes (probably related to some form of allergies). These problems are usually outcomes of "indoor air pollution". "Indoor air pollution" may be present, actually or perceived, in an air-tight house which does not have adequate ventilation.

Potential Impacts

Health considerations may impact on the demand for energy saving measures in two ways. First, there has been a widespread "scare" about urea formaldehyde foam. Even though this form of insulation was only used in the retrofit of old houses, there could be repercussions on the demand for other types of energy saving measures in new homes. The second type of impact is partly economic. There are certain measures, such as airtightness, which must be accompanied by other measures to avoid "side effects". In the case of high airtightness levels, a ventilation system must be installed, which adds to the costs and lowers the effectiveness of the original measure.

Current Status

There is concern over "indoor air pollution". A federal-provincial Task Force is investigating the problem with an ultimate objective of setting standards.

"Indoor air pollution" is exacerbated by such energy saving measures as air-tightness, but stems mainly from the by-products of daily living. Humidity, CO_2, cooking and other odours, combustion by-products that are not carried

away by the flue, and radon (a naturally occurring radio-active gas found in various locations) contribute to "indoor air pollution". The use of synthetics in the construction of the house and its furnishings also adds to indoor air pollution.

Geographical Aspects

None.

Future Trends

At this time, there is a move towards better ventilation systems in buildings with improved airtightness. More information regarding levels of indoor air pollution will be recommended by the Task Force. The need for stepped-up further research is pointed out in the Report.

7. POTENTIAL DAMAGE TO STRUCTURE AND CONTENTS

Definition

"Damage to structure and contents" means any damage to the structure or contents of the house due to the incorporation of energy saving measures.

Potential Impacts

Consumers would understandably be reluctant to install energy saving measures if they thought that damage will occur as the result. This would act as a negative factor if the expectation was unfounded. Of course, if the expectation of damage was correct, appropriate preventative measures must be taken. This factor would then change its character from non-economic to economic and, being negative in that category, would probably outweigh the positive impacts of energy saving.

Current Status

Damage may occur due to high levels of airtightness without appropriate ventilation. When air change rates are too low, high humidity can cause damage in two ways: (1) interior condensation can cause molds on walls and frost on cold surfaces and (2) interstitial condensation can cause damage where humid inside air is allowed to leak through unwanted paths in the walls and cool down, thus losing its moisture.

With properly designed and installed vapour barriers and appropriate ventilation this damage can be avoided.

Furnishings may become faded due to the extra sunlight that a house with a southern orientation could receive.

Geographical Aspects

In those pa rts of the country which receive more sun during the winter months (e.g., Calgary), the fading of house contents could be a greater problem.

Future Trends

A federal-provincial task force, as well as the National Research Council and Health and Welfare Canada, are studying indoor air-pollution with a view to setting air quality standards and defining the required number of air changes. A more widespread use of ventilation systems will help to reduce condensation and structural damage.

8. INTERIOR COMFORT

Definition

Comfort is closely related to health considerations, but usually covers conditions that have no specific physical impact.

Comfort is affected by such factors as: the temperature of the air, the amount of humidity, air circulation/ventilation, feelings of claustrophobia, drafts, noise and smells.

Potential Impacts

If the consumer perceived that he or she might be less comfortable as a result of some energy saving measure, the measure may not be installed.

Current Status

Testing for interior comfort is very difficult as its measurement depends on the subjective assessment of people with varying physical needs.

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) has developed some comfort guidelines. Five factors affect indoor comfort:

- air temperature
- surface temperature
- relative humidity
- air movement
- clothing insulation.

For average clothing and activity (i.e., office work) the most commonly recommended design conditions for comfort are:

Effective Temperature	=	24°C
Relative Humidity	=	40% (20 to 60 range)
Air velocity	=	less than .23 m/s (45fpm)*

These levels would be appropriate for watching television, and reading, but not for heavy housework. The choice of an air tight house with a ventilation system as an alternative to a "leaky" house, does not adversely affect humidity levels or the associated comfort. However, fans might be somewhat noisy and bother some people.

Geographical Aspects

None.

Future Trends

None.

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* ASHRAE Fundamentals Handbook - Chapter 8, Physiological Principles of Comfort and Health, p. 8.22.

9. SUMMER EFFECTS

Definition

"Summer effects" have specific implications on comfort during the summer, which result from having measures designed to save energy in the winter. Heat pumps are an obvious example of an energy saving measure which has implications for summer comfort as they provide air conditioning benefits.

Potential Impacts

Energy saving measures may create positive and some negative impacts in the summer months. For example, airtightness and insulation will keep the house cooler in the summer. On the other hand, insulation in the basement floor may theoretically reduce the cooling characteristics of the basement in the summer.

Current Status

The heat pump's air conditioning feature makes it an economical alternative to conventional heating plus air conditioning equipment. Unless the consumer had planned to install conventional air conditioning, a heat pump would, however, usually not be financially attractive. Consequently, the summer effect associated with heat pumps is the aspect which makes them economically attractive.

Some consumers think that passive solar features make the house too warm in the summer.

Geographical Aspects

None.

Future Trends

None.

10. AESTHETICS

Definition

Aesthetics are the visual appeal or attractiveness of the house for the prospective owner. Such factors as smells and comfort have been covered under Interior Comfort.

Potential Impacts

If the installation of an energy saving measure adversely affected the appearance of the house, the consumer may be unwilling to install it. On the other hand, some aesthetically appealing features such as fireplaces, are not energy efficient and would not be used in a highly energy efficient house.

Some examples of aesthetic problems might be:

- no gables or other irregular shapes in design
- small windows on the north side of the house
- no fireplaces
- solar heating panels
- awkward positioning of the house on the lot
- thick walls due to added insulation.

If the installation of certain features requires camouflaging to maintain the attractiveness of the house, accommodating the aesthetic factor will mean additional costs.

Current Status

Aesthetics play a minor role in the decision to install an energy saving measure. Fireplaces are very popular. Rather than dispensing with them, many

people are compromising by installing heatilators, a device which recirculates the warm air into the room.

Thick walls (2 x 6) are common in new construction as this is a cost effective way of installing extra insulation. There has been no negative reaction from consumers. According to one builder, some consumers expect to and want to see thick walls as a visual confirmation of the amount of insulation installed.

Geographical Aspects

Wood stoves, which have an aesthetic appeal, are a popular response in Halifax and Vancouver to the perceived need for saving non-renewable energy. Wood is readily available in both cities. Whether or not the use of wood as an alternate fuel is cost-effective, the positive impact of aesthetics on the choice of energy-saving behaviours is notable.

Future Trends

None.

11. SOCIAL IMAGE

Definition

Social image implies a peer group collective opinion of a product and of the person who buys the product. The installation of an energy saving measure may be the result of a desire to "conspicuously consume" conservation measures for the sake of a good social image.

Potential Impacts

Social image may be one of the criteria the consumer uses to choose an energy saving measure and may over-ride economic considerations. For example, the consumer may install a heat pump which is less cost-effective than another measure simply because it is a visible and it is a known to conserve energy in the winter.

Current Status

A published survey indicates that some energy saving measures have a good "social image"*. When asked if solar heating would enhance the image of a house or apartment, nearly one-half of those surveyed said it would make the dwelling more attractive.

Geographical Aspects

None.

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* A "Study of the Canadian Public's Attitudes Toward Specific Energy Issues Facing Canadians," Conducted for Energy, Mines and Resources, May 1978.

Future Trends

None.

12. REPUTATION OF PRODUCT WITH THE CONSUMER

Definition

The reputation of an energy saving measure is the consumer's opinion of the reliability, effectiveness and value of the measure.

Potential Impacts

The better the reputation of the product, the more likely that the consumer will install it.

Current Status

In general, this does not seem to be an important factor inhibiting or helping the installation of energy saving measures. Regardless of the urea formaldehyde foam scare, the reputation of other forms of insulation is high. However, some consumers may not understand that urea formaldehyde is exclusively a retrofit material, and is not used in new houses. Some consumers have questioned the reliability of heat pumps.

Details of consumer's opinions on energy saving features are included in the results of the consumer survey, discussed in Appendix E.

Geographical Aspects

None.

Future Trends

None.

C. INSTITUTIONAL FACTORS

13. PROPERTY TAXES

Definition

The property taxes considered below are additional taxes levied on homeowners as a consequence of having energy saving measures.

Potential Impacts

Arguments have been put forward theorizing that the inclusion of energy saving measures may result in higher property tax assessments. This would make the economics of the energy saving measures less attractive to the consumer.

The assessment may be greater for a house with energy saving measures because:

- the market value of the house with energy saving measures may be greater than of a similar house without them
- with the addition of insulation, the square footage of the house, using the outside dimensions, may increase
- more land may be needed for passive solar heating purposes.

Current Status

Property taxes are generally calculated on the basis of the square footage of the house, the amount of land on which the house is situated, as well as the value of the house. The installation of a heat pump by one home owner in

the survey was deemed to add value to his home because of its air conditioning feature. His assessment was raised accordingly.

Geographical Aspects

There are different assessment practices among jurisdictions. An attempt to counter the negative impact property taxes may have on the economics of energy-saving measures may require changes in rules. The most appropriate steps which could be taken to lessen the impacts would have to be investigated by jurisdiction.

Future Trends

None.

14. BUILDING CODES AND STANDARDS

Definition

Building codes and standards are defined as those applicable to residential buildings.

Potential Impacts

There have been arguments that building codes and standards may adversely affect the cost of installing certain energy-saving measures. Consequently, builders and/or tradesman may be unwilling to install a measure in the way recommended by the building code, due to added costs or inconvenience.

Current Status

There is nothing in the building codes which inhibits the installation of energy saving measures.

Geographical Aspects

Throughout the seventies there has been a trend in responsibility for the formulation of building bylaws away from municipalities to the provincial levels. British Columbia, Alberta, Manitoba and Ontario have mandatory codes. Municipalities in these provinces are believed to enforce the codes uniformly. In Quebec, small residential structures are exempted, but municipalities which formulate their own codes adopt provisions for such structures at least as stringent as the provincial code. In B.C., Vancouver, as a Charter City, is exempt, but has in fact adopted the National Building Code (NBC). In Saskatchewan, municipalities have the right to amend the provincial code. In New Brunswick, municipalities are required to adhere to the NBC. In Prince Edward Island, the two major urban areas use the NBC as their bylaws. In Newfound

land, the provincial government encourages all municipalities to adopt the NBC as a basis for their bylaws.

Future Trends

None.

15. AVAILABILITY OF INFORMATION TO THE PUBLIC

Definition

The "availability" of information on energy saving measures means widespread availability which creates consumer awareness. It also means availability of information from those involved in the delivery process, i.e., builders, suppliers and real estate agents.

Potential Impacts

The availability of complete and accurate information will affect general consumer interest and the consumers' ability to make a decision about a specific feature. Both of these aspects will affect consumer demand.

Current Status

Provincial and federal governments, sometimes in conjunction with building associations, are the major source of public information about energy saving measures. This information ranges from general descriptions of the energy saving measures available, to detailed booklets explaining the workings of a feature and the proper installation procedures to be followed.

Geographical Aspects

There seems to be somewhat more consumer awareness of energy saving features in Ottawa than elsewhere. This may be due partly to the presence of a number of agencies which research and publish information about energy saving.

Future Trends

The dissemination of information via the public media and through those involved in the delivery of the energy saving measure may be slowed if interest wanes due to falling oil prices.

16. EXPECTATIONS REGARDING FUTURE ENERGY PRICES

Definition

Uncertainty may be viewed as the consumer's expected variance of energy prices.

Potential Impacts

The rational consumer will forecast future energy bill savings gained from an energy saving measure. The more uncertain the consumers are of future energy prices and consequently savings, the higher the discount rate they will apply to the future stream of savings. Consequently, the greater the uncertainty about future energy prices, the higher the consumers' expected "most likely" future energy price level must be to decide on an energy saving measure. By itself uncertainty has a negative impact on the demand for energy saving measures.

Current Status

The future of oil and gas prices in Canada is dictated by the National Energy Program (NEP). To the extent that consumers believe this will remain in place, the uncertainty about future prices is diminished.

The question of future supply and prices is, however, a controversial subject as many mega-projects have been cancelled. Also OPEC has shown signs of weakening recently. Consequently, the projections of future energy prices implied in the NEP has, at least temporarily, lost some credibililty.

A recent survey of homebuyers using the CHIP retrofit program for insulation found that individuals considered mainly past heating bills in their decision to invest in insulation, without trying to predict the future. This finding

might have less relevance for those who are first-time homebuyers and have no experience with home heating bills.

Geographical Aspects

None.

Future Trends

None.

17. INCENTIVE OR DISINCENTIVE PRICING BY UTILITIES

Definition

The word "incentive" is defined here as inducing consumers to use more energy, not to save more. It relates to the utilities' pricing policies that are based on average costs. During peak periods the actual cost of producing incremental amounts of energy is higher than the average cost. For that reason, the consumers consider lower energy prices when they calculate the impacts of energy saving measures than the cost savings actually occurring in the system. During off-peak periods the actual costs of producing electricity are often lower than the average; failing to pass on this difference to the consumer may cause inefficient allocations of resources.

Potential Impacts

This factor reduces the economic incentive to buy energy saving measures. There are two sources of artificiality in pricing. One is that utility rates decrease rather than increase with higher consumption, despite the opposite direction of change in costs, which increase with higher levels of production. Thus, energy pricing gives misleading signals to the consumer, causing the energy savings seen by the consumer to be underestimated in relation to the true savings in the system.

The other issue is off-peak pricing. There are large capital costs involved in supplying energy for uses with low load factors. As few utilities price energy according to the time of day or time of year when it is used, there is no incentive for the consumer to use surplus during off-peak periods. Appropriate off-peak rates could induce consumers with gas or oil furnaces to use electrical heaters during daylight hours when substantial surplus hydro or nuclear capacity is available in many parts of Canada and thereby save fossil fuels without consuming any corresponding resources in the electrical sector.

Current Status

All utilities use average cost pricing.

Geographical Aspects

Off-peak pricing of electricity would save energy where hydro or nuclear capacity is being wasted during off-peak hours.

Future Trends

No indication of changes.

18. UTILITY/REGULATORY POLICIES TO MINIMIZE RATES AND INCREASE SALES

Definition

Utilities endeavour to sell more energy at a lower price rather than obtain their revenue requirements by selling less energy at a higher price in those markets in which this might be feasible. This objective is usually supported by the regulatory process.

Potential Impacts

As utilities want to maximize revenue, and the regulatory process tends to keep rates at the minimum, consumers face a set of prices that do not provide maximum incentives for installing energy saving measures. This conflicts with the social goal of conserving a depleting supply of energy.

Current Status

Energy pricing is largely a matter of policy. At the present, the regulatory process still works toward the traditional objective of minimizing rate increases and implies that all conservation incentives by means of energy pricing and taxation should be provided by government policy and not by regulation.

Geographical Aspects

None.

Future Trends

None.

APPENDIX E

RESULTS OF THE SURVEY OF CONSUMERS AND BUILDERS

APPENDIX E

RESULTS OF THE SURVEYS OF CONSUMERS AND BUILDERS

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APPENDIX E

RESULTS OF THE SURVEY OF CONSUMERS AND BUILDERS

INTRODUCTION

A survey of builders and of recent buyers of new homes was carried out in late 1982 to identify the barriers to the penetration of energy saving measures that may exist in today's market.

Six cities were covered in the surveys: Halifax, Montreal, Ottawa, Toronto, Calgary and Vancouver. As a preliminary phase, interviews were conducted with builders in these cities. The interviews served two purposes:

1. To gather supply side perceptions of energy efficiency.

2. To obtain lists of potential respondents for the consumer survey.

The survey of builders focused on the following questions:

1. Which energy saving measures were offered as standard, or on request?

2. Were there any problems with the installation or maintenance of energy saving measures?

3. How inclined was the builder to install energy saving measures?

4. Was an energy saving measure used by the builder as part of his marketing strategy?

5. Was adequate information available to the buyer about energy saving measures?

The consumer survey provided qualitative data on the demand-side perception of energy saving measures. Following a literature review of the potential factors inhibiting the ownership of energy saving measures, and building a financial/ economic framework of consumer behaviour as a guide, questions were formulated around four areas, concentrating particularly on the first two:

1. Which of the following energy saving measures are actually installed in the respondents' house?

    1. Improved efficiency furnace
    2. Extra insulation
    3. Airtightness
    4. Passive solar layout
    5. Nighttime setback thermostat
    6. Heat pump.

    If they did not have each of these measures, why not?

2. How valid are any potential problems with energy saving measures that had been raised in the published literature or elsewhere?

3. What is the financial evaluation process used by the consumers, including their time horizon, to evaluate home ownership costs?

4. What is the consumers' perception of energy prices and their general interest in energy saving measures?

METHODOLOGY

Twenty-two telephone interviews were conducted with builders. The names of potential respondents were obtained from the local builders' association in each city (Housing and Urban Development Association of Canada). Large,

EXHIBIT E-1

NUMBER OF RESPONDENTS BY CITY

HALIFAX	11
MONTREAL	13
OTTAWA	10
TORONTO	28
CALGARY	14
VANCOUVER	12
TOTAL	88

medium and small* builders were interviewed including custom builders. Efforts were made to interview "representative" builders, i.e. interviews with builders who were specially involved in promoting energy saving were avoided.

Telephone interviews with consumers were conducted in the evenings. An interview lasted approximately 20 minutes. Eighty-eight interviews were completed and analyzed. (See Exhibit E-1.) The objective of the survey was to provide an understanding of people's attitudes in a qualitative rather than quantitative manner. The survey was intended to be only exploratory and not an accurate representation of the total population of Canada. For that reason no statistical tests were applied to the results and no inference was drawn from the quantitative findings to the totality of the population, even within the cities surveyed.

A. RESULTS OF THE CONSUMER SURVEY

1. General Characteristics

a) Method of Sale

Contrary to the recent trend away from the use of model homes as a method of sale, it was found that still about one-third of the respondents had seen a model home and another third had purchased a house which was already built (see Exhibit E-2).

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* Size was measured by the annual number of houses built.

EXHIBIT E-2

METHOD OF SALE

	# of Homes
Custom Built	9
Saw Model	27
Saw Plans	21
Already Built	31
TOTAL	88

PRIMARY METHOD OF HEATING

	# of Homes
Gas	63
Electricity	17 (Halifax, Montreal Toronto*)
Oil	7 (Halifax)
Wood	1 (Halifax)
TOTAL	88

* Heat pump.

EXHIBIT E-3

NUMBER OF
ENERGY SAVING MEASURES INSTALLED BY CITY

City	Number of Houses	Improved Efficiency Furnace	Extra Insulation ([1])	Timed Thermostat	Heat Pump	Air Tightness	Passive Solar Layout	ALL MEASURES		ALL EXCEPT THERMOSTAT AND PASSIVE SOLAR	
								Total Number	Per Household	Total Number	Per Household
Halifax	11	6	6	2	1	3	2	20	1.82	16	1.45
Montreal	13	0	5	3	1	2	4	15	1.15([3])	8	0.61([3])
Ottawa	10	4	7	2	1	5	5	24	2.40	17	1.70
Toronto	28	8	13	12	6	8	10	57	2.04	35	1.25
Calgary	14	9	3	6	0	6	5	29	2.07	18	1.29
Vancouver	12	3	0	4	0	1	3	11	0.91	4	0.33
TOTAL	88	30	34	29	9	25	29				
Number Per Household		.40([2])	.38	.33	.10	.28	.33				

([1]) Including those who did not say they had extra insulation but, in fact, had more than the "basic" level defined in this study.

([2]) Montreal excluded (no gas or oil furnace economical).

([3]) Low figure for Montreal indicates no opportunity for improved efficiency gas or oil furnace.

b) Form of Heating

Natural gas is by far the most common method of home heating west of Quebec (see Exhibit E-2). The nearly exclusive use of electricity in Montreal was expected. The use of both oil and electricity in Halifax can be attributed to the small difference between the costs of the two forms of heating.

Although not shown in Exhibit E-2, wood stoves were a popular supplementary form of heating in Halifax and Vancouver. Wood is readily available in these two cities. The economies of using wood are not necessarily favourable, especially if one considers the opportunity costs of the consumer's time. The use of wood may be perceived as a means of conserving non-renewable energy.

When a choice is available, builders usually let consumers choose the heating form.

c) Selection of the Respondent

We asked to interview the member of the household who was most familiar with the subject. Two-thirds of the respondents were male.

2. Number of Energy Saving Measures Installed

The number of energy saving measures installed by respondents is shown by city in Exhibit E-3.

The order of "popularity" of the measures in the new homes was:

- improved efficiency furnaces
- nighttime setback thermostats

- passive solar layout
- above-average air tightness
- extra insulation
- heat pump.

However, as discussed later, it was found that many respondents who did not consider themselves as having "extra" insulation in fact had. According to the definition of "base" insulation levels used in this report, in fact 55% of the households had "extra" insulation, which moves this measure into first place.

Vancouver showed the lowest incidence of energy saving measures, due obviously to its mild climate. Somewhat surprisingly, Calgary showed about equal propensity to that of Eastern/Central Canada, in spite of very low gas rates. Montreal showed a low propensity, partly because of electric heating that does not permit the installation of improved efficiency furnaces, while the electrical equivalent of such furnaces, the heat pump, has not penetrated the Montreal market very strongly.

A breakdown by various consumer characteristics is provided below.

a) First-time and Repeat Homebuyers

The first-time homebuyer typically has very little equity in the home and typically uses a five-year time horizon for financial decision-making. Eighty-three percent of the first-time homebuyers used this time horizon or less. The dominant factor for such a person, when considering the purchase of an energy saving or any other feature, is likely to be the additional monthly carrying cost of the feature.

It appeared logical that this budget constraint combined with inexperience with the relative size of heating bills would make energy features less attractive to the first-time homebuyers than to repeat buyers. As can be seen from Exhibit E-4, this seems to be the case, particularly when the measures with very little investment cost are excluded.

The most popular energy saving measure for the first-time homebuyer was the nighttime setback thermostat - the cheapest measure available. Passive solar layout, or simply the orientation of the largest window area towards the south, was the second most popular measure for the first-time homebuyer. The fairly high incidence of above-average airtightness was not surprising, as many builders reported that most houses built recently were "tighter" than houses built 5 to 10 years ago.

A somewhat surprising finding was the relatively high number of improved efficiency furnaces owned by first-time homebuyers (20%) considering that they have no experience with heating bills. Again, builder practices may help to explain this result. Several large builders install improved efficiency furnaces as a standard.

The consumers' opinion on the question whether they felt that an energy saving measure would increase the re-sale value of the home, was mixed, as shown in Exhibit E-8.

b) House Price, Income and Age

The number of energy saving measures installed depends relatively little on house prices, except for the lowest and highest price groups. (See Exhibit E-5.) Exhibit E-6 shows the pattern by income. There is no significant correlation. Exhibit 7 shows the number of

EXHIBIT E-4

NUMBER OF ENERGY SAVING MEASURES INSTALLED

	IMPROVED EFFICIENCY FURNACE	EXTRA INSULATION	TIMED THERMO-STAT	HEAT PUMP	AIR TIGHTNESS	PASSIVE SOLAR LAYOUT	ALL MEASURES		ALL EXCEPT THERMOSTAT AND PASSIVE SOLAR	
							TOTAL NUMBER	PER HOUSE-HOLD	TOTAL NUMBER	PER HOUSE-HOLD
35 FIRST TIME HOMEBUYERS	7	5	14	2	11	13	52	1.48	25	0.48
53 REPEAT HOME-BUYERS	23	14	15	7	14	16	89	1.68	58	1.09
TOTAL INSTALLED	30	19	29	9	25	29	141	1.60	83	0.94
NUMBER OF MEASURES THAT "CAME WITH THE HOUSE"	10	2	12	4	5	18	51	0.58	21	0.24

EXHIBIT E-5

NUMBER OF ENERGY SAVING MEASURES INSTALLED BY HOUSE PRICE

House Price ($000)	Number in Sample	Improved Efficiency Furnace	Extra Insulation	Heat Pump	Air Tightness	Total Number of Measures	Measures Per Household
45-60	6	0	2	1	0	3	0.5
60-80	12	3	3	0	6	12	1.0
80-100	19	10	9	1	5	25	1.3
100-150	32	9	13	1	9	32	1.0
150-250	13	7	6	5	4	22	1.7
Over 250	2	1	1	0	1	3	1.5

4 households withheld price information.

EXHIBIT E-6

NUMBER OF ENERGY SAVING MEASURES INSTALLED BY INCOME CLASS

Income	Number in Sample	Improved Efficiency Furnace	Extra Insulation	Heat Pump	Air Tightness	Total Number of Measures	Measures Per Household
20-35	20	3	7	1	7	18	0.90
35-50	19	10	8	4	6	28	1.47
50+	36	12	18	3	9	42	1.17

13 households witheld income information

EXHIBIT E-7

NUMBER OF ENERGY SAVING MEASURES INSTALLED BY AGE GROUP

Age	Number in Sample	Improved Efficiency Furnace	Extra Insulation	Heat Pump	Air Tightness	Total Measures	Measures Per Household
20-30	34	8	9	3	12	32	.94
31-40	37	12	18	2	8	40	1.08
41-50	12	7	4	3	3	17	1.40
Over 50	5	3	3	1	2	9	1.80
TOTAL	88	30	34	9	25	98	1.11

EXHIBIT E-8

PERCENTAGE OF RESPONDENTS WHO STATED MEASURES WOULD NOT ADD TO RESALE VALUE OF HOUSE

	IMPROVED EFFICIENCY FURNACE	EXTRA INSULATION	HEAT PUMP	AIR TIGHTNESS	PASSIVE SOLAR LAYOUT
WILL NOT ADD:	31 %	33 %	41 %	45 %	51 %
DON'T KNOW:	11 %	3 %	25 %	23 %	16 %
WILL ADD:	58 %	64 %	34 %	32 %	33 %
TOTAL	100 %	100 %	100 %	100 %	100 %

energy saving measures installed by age group. Note that the following exhibits combine those respondents who said that they had higher then the "basic" level of insulation and those who did not say so but actually had higher levels.

3. Reasons Given for Not Owning an Energy Saving Measure

Exhibit E-8 shows the percentage of respondents who stated that energy saving measures would add to the resale value of their house. About 60% of the respondents thought that improved efficiency furnaces and extra insulation would add to the resale value of the house. However, the majority of people thought that heat pumps, airtightness and passive solar layout would not add to the resale value of the house.

Exhibit E-9, and Exhibit E-9A, show the reasons cited for not owning an energy saving measure. As reflected in the resale value question, the most common reason for refusing energy saving measures was the belief that they "did not pay".

The response "did not know enough about it" was most common for heat pumps, airtightness and passive solar layouts.

Exhibit E-10 shows that consumers considered the "basic" level of insulation to be quite high. Therefore, the high number of responses that "extra" insulation does not pay" is consistent with the perception that basic levels are already adequate and, actually relates to levels of insulation substantially above the basic level defined in this report. This is confirmed by Exhibit E-18, later in this Appendix.

EXHIBIT E-9

REASONS GIVEN FOR NOT OWNING OR OPTING FOR AN ENERGY SAVING MEASURE

	IMPROVED EFFICIENCY FURNACE	EXTRA INSULATION	TIMED THERM.
DOESN'T PAY	5	24	7
DOESN'T WORK	0	0	2
DID NOT THINK OF IT	1	3	7
DIDN'T KNOW ENOUGH ABOUT IT	3	1	1
HAS DISADVANTAGES	2	0	1
COULDN'T AFFORD IT	1	0	0
INSTALLING IT MYSELF	1	5	3
TOTAL	13	33	21
WOULD HAVE TAKEN BUT NOT OFFERED	6	22	30
MIGHT OR MIGHT NOT HAVE TAKEN IF OFFERED	2	4	3
HOUSE ALREADY BUILT	3	6	5*
HAS MEASURE	30	19	29
NOT SURE WHAT IT MEANS	34	4	0
TOTAL	88	88	88

* In the case of the thermostat, these people have decided to turn down the heat manually.

EXHIBIT E-9a

REASONS GIVEN FOR NOT OWNING AN ENERGY SAVING MEASURE (Continued)

	HEAT PUMP	AIR TIGHTNESS	PASSIVE SOLAR
DOESN'T PAY	14	3	7
DOESN'T WORK	4	2	2
DID NOT THINK OF IT	5	3	3
DIDN'T KNOW ENOUGH ABOUT IT	8	3	5
HAS DISADVANTAGES	0	4	1
COULDN'T AFFORD IT	5	0	4
INSTALLING IT MYSELF	3	1	1
UGLY	0	0	5
TOTAL	39	16	28
WOULD HAVE TAKEN BUT NOT OFFERED	11	14	15
MIGHT OR MIGHT NOT HAVE TAKEN IF OFFERED	16	6	12
HOUSE ALREADY BUILT	0	1	4
HAS MEASURE	9	25	29
NOT SURE WHAT IT MEANS	13	26	0
TOTAL	88	88	88

EXHIBIT E-10

CONSUMERS PERCEPTION OF WHAT IS THE BASIC LEVEL OF INSULATION

	LEVEL DEFINED IN STUDY					
CITY	LESS THAN 1	1	1-2	2	3	DON'T KNOW
HALIFAX	1	5				5
MONTREAL	2	3				8
OTTAWA	1	3	1	3		2
TORONTO	10	2	2	2		12
CALGARY	4			1	1	8
VANCOUVER	9	—	—	—	—	3
	27	13	3	6	1	38

4. Concerns About Energy Saving Measures

Specific questions were asked about possible concerns with energy saving measures (see Exhibit E-11, and Questionnaire). Thirty-eight percent of the respondents noted their awareness of problems that were encountered with urea formaldehyde foam but did not specifically associate this problem with new construction.

The next most commonly cited issue was the view that passive solar layout would make the house too hot in the summer. This was followed by the health issue associated with airtightness. Both issues were solicited.

About 20% of the respondents felt that there were health risks associated with increased airtightness, regardless of exhaust systems. Another 10% felt that such problems exist only without installed exhaust systems.

The study team thought that consumers might dislike cool temperatures at night and avoid installing a nightime setback thermostat. However, the majority of respondents said they preferred the house cooler at night.

5. Consumer Decision-making

By far the most common estimate of the amount of time included in calculations of homeownership costs was 5 years; 64% of the sample used a time horizon of 5 years or less (see Exhibit E-12). For another 13%, the time horizon was 6 to 10 years.

This result is consistent with the suggestion that repeat homebuyers use similar time horizons for financial decision-making, as first-

EXHIBIT E-11

NUMBER OF CONCERNS ABOUT ENERGY SAVING MEASURES

MEASURES

Improved Efficiency Furnace	Extra Insulation	Timed Therm.	Heat Pump	Air Tightness	Passive Solar
Want Chimney	More Taxes	Cool[2] Nights	More Taxes	Health Problems	Too Hot In Summer
18	7	3	12	14 with exhaust 23 without exhaust	23
	Fire				
	2				
Other Problems	Other Problems[1]		Other Problems[3]	Other Problems[4]	Other Problems[5]
3	34		8	13	15

1 38% of the respondents mentioned Urea Formaldehyde Foam, 9 respondents mentioned problems related to indoor air pollution, eg., allergies, stale air, dry, hot air.

2 53% of the respondents said they prefer it cooler at night.

3 6 respondents mentioned maintenance problems.

4 13 respondents mentioned indoor air pollution.

5 4 respondents thought there would be a heat loss in winter, 3 respondents noted that houses in the city are too close together to make effective use of passive solar features, 6 noted layout and design limitations.

EXHIBIT E-12

NUMBER OF YEARS CONSIDERED IN FINANCIAL PLANNING FOR HOME OWNERSHIP

NUMBER OF RESPONDENTS	NUMBER OF YEARS
4	0
10	1
8	2
8	3
3	4
23	5
10	10
2	15
2	20
3	25
1	27
1	50
13	MISSING

73 SAID THEY MADE CALCULATIONS ON PAPER
15 SAID THEY DID NOT

EXHIBIT E-13

NUMBER OF RESPONDENTS CONSIDERING HOME OWNERSHIP COSTS

City	Number of Houses	Mortgage	Property Taxes	Energy	Maintenance Repair	Rising Value of House
Halifax	11	10	9	8	7	5
Montreal	13	12	13	12	12	11
Ottawa	10	10	10	9	6	8
Toronto	28	26	25	24	13	16
Calgary	14	13	12	8	4	7
Vancouver	12	9	9	7	6	8
TOTAL	88	80	78	68	48	55

time homebuyers. Of the 35 first-time homebuyers interviewed, 68% had a time horizon of 5 years or less.

Regardless of the use of short time horizons of some repeat homebuyers, the number of energy saving measures owned by them is higher than the number owned by first-time homebuyers. This indicates that the time horizon of a homebuyer is not a strong factor in the decision to own an energy saving measure.

Eighty-three percent of the respondents said they made calculations on paper when they were planning their homeownership. Exhibit E-13, shows the types of expenses that respondents considered. Few respondents took the maintenance or repair costs of the house, or the rising value of the house into consideration. As might be expected, energy costs were considered to a lesser degree in Calgary and Vancouver than elsewhere. This is logical, since energy is relatively cheap in Calgary and the climate is relatively temperate in Vancouver. Ninety-one percent of the respondents considered mortgage payments.

6. Consumers' General Interest in Energy Saving Measures and Awarenes of Energy Prices

Exhibit E-14 indicates consumer interest in energy saving measures. This Exhibit shows the number of respondents who said that they might have taken an energy saving measure if it had been offered by the builder. The most popular energy saving measures were the improved efficiency furnace, extra insulation and the nighttime setback thermostat. It should be kept in mind, however, that the view of a respondent in a theoretical situation may be different from a situation when confronted with the actual costs and details of the item in question.

EXHIBIT E-14

CONSUMER INTEREST IN ENERGY SAVING MEASURES

NUMBER OF RESPONDENTS WHO WOULD HAVE TAKEN MEASURE IF OFFERED BY BUILDER

	IMPROVED EFFICIENCY FURNACE	EXTRA INSULATION	TIMED THERM.	HEAT PUMP	AIR TIGHTNESS
POTENTIAL BUYERS	6	22	30	11	14
TOTAL CASES BUILDER MADE NO OFFER*	48	48	52	68	63
POTENTIAL BUYERS AS A % OF CASES WITH NO OFFER	13	45	58	16	22

* Factored up by ratio of respondents who "did not remember" whether measure was offered.

EXHIBIT E-15

CASES IN WHICH BUILDER OFFERED OR PROVIDED ENERGY SAVING OPTIONS

	IMPROVED EFFICIENCY FURNACE	EXTRA INSULATION	TIMED THERM.	HEAT PUMP	AIR TIGHTNESS
NUMBER OF TIMES OFFERED	37	40	35	17	25
TOTAL RELAVANT CASES*	75**	88	88	88	88
PERCENT OF TIME BUILDERS OFFERED PTION	49	45	40	19	28

* Includes accepted and refused. The numbers who refused were factored up by ratio of respondents who "did not remember" whether measure was offered.

** Excludes Montreal

Exhibit E-15 shows the number of cases in which the builder offered an energy saving measure as an option. The Exhibit shows that the inclusion of the measures on the options lists was relatively rare.

Eighty-one percent of the respondents stated that they had read published material on energy saving measures.

Exhibit E-16 shows that 65% of the respondents thought that a shortage of natural gas was unlikely. Consistent with this view, only 22% thought that the price of natural gas* would rise much faster than inflation (see Exhibit E-17).

CONCLUSIONS OF CONSUMER SURVEY

- A reasonably high percentage of people now purchase homes with energy saving measures.

- In those regions in which energy saving measures are economically advantageous, there is greater interest.

- 50% of the respondents in Eastern/Central cities had insulation above the "basic" level as defined in this study, although many thought that what they have is the "basic" level.

- The number of respondents with improved furnaces was 40%. The percentages were somewhat lower (28-33%) for nighttime setback thermostats, improved air tightness and passive solar layouts.

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* The respondents in Halifax were asked about oil, not gas.

EXHIBIT E-16

HOW MANY PEOPLE THINK A SHORTAGE OF NATURAL GAS* IS:

	PROBABLE	NOT LIKELY	DON'T KNOW	TOTAL ASKED
HALIFAX	3	6	2	11
MONTREAL	2	7	4	13
OTTAWA		10		10
TORONTO	6	19	2	27
CALGARY	3	10	1	14
VANCOUVER	6	5	1	12
TOTAL	20	57	10	87

1 OBSERVATION MISSING

* OIL IN HALIFAX

EXHIBIT E-17

HOW MANY PEOPLE THINK THE PRICE OF NATURAL GAS* WILL RISE RELATIVE TO INFLATION

	MUCH FASTER THAN INFLATION	LITTLE FASTER THAN INFLATION	WITH INFLATION	TOTAL ASKED
HALIFAX	3	2	6	11
MONTREAL	3	1	9	13
OTTAWA	4	2	4	10
TORONTO	8	9	9	26
CALGARY	1	7	6	14
VANCOUVER	2	2	7	11
TOTAL	21	13	41	85

3 OBSERVATIONS MISSING

* OIL IN HALIFAX

- Reasons for not owning energy saving measures were (in this order):

  - "doesn't pay"
  - "didn't know enough about it..."
  - "installing it myself...".

- About one-half of the respondents said they might have taken some of the energy saving measures that they had not requested if such measures had been offered by the builder.

- Most people (64%) based their financial planning on five years.

A sample of the survey questionnaire is provided as in Appendix G.

B. RESULTS OF THE BUILDER SURVEY

1. Energy Saving Measures Installed as Standard or on Request

Twenty-two builders were interviewed in Halifax, Montreal, Ottawa, Toronto, Calgary and Vancouver.

The number and type of energy saving measures installed by the builders are summarized in Exhibit E-20/a to E-20/f at the end of the Appendix (page 231 to 236). There is a table for each city and the interviewed builders are categorized by size. As in the consumer survey, geographical location explains a great deal about the incidence of energy saving measures. Ottawa and Halifax builders install the highest levels of insulation, followed, in that order, by Toronto, Montreal, Calgary and Vancouver. (See Exhibit E-18.)

EXHIBIT E-18

BUILDER INTERVIEWS

STANDARD LEVELS OF INSULATION OFFERED

(Levels defined in this study)

CITY	LESS THAN 1	1	1-2	2	TOTAL
HALIFAX		4			4
MONTREAL	3	2			5
OTTAWA		1		2	3
TORONTO	1	2			3
CALGARY	2	1			3
VANCOUVER	4				4

Builders did not perceive airtightness as an "option" which could be varied from house to house (with the exception of one Ottawa builder). Instead, builders viewed airtightness as part of their general building practices.

Two of five Montreal builders interviewed installed exhaust systems as standard. This is likely due to the use of electric heating which does not require a chimney. Houses would, therefore, be insufficiently ventilated without an exhaust fan.

Very few heat pumps are installed by builders, but are offered on a "request only" basis in Toronto, Ottawa and Montreal. One custom builder in Toronto has installed heat pumps as a standard, but only in the very latest subdivision.

Improved efficiency furnaces are offered by several builders (mostly large companies) as a standard, mostly in Toronto and Calgary. One Toronto builder stated that the improved efficiency furnace was installed as a standard only in houses costing $90,000-$150,000. Four builders said that they installed improved efficiency furnaces on request.

2. Problems with Installation or Maintenance of Energy Saving Measures

If an energy measure needs time consuming installation, or has potential maintenance problems after installation, it is unlikely to be installed by a builder. However, no energy saving measure was found to cause very significant problems for the builders. Builders confirmed that vapour barriers take a little more time and supervision to be installed properly, but there was no general "complaint" about the installation of vapour barriers.

Seven builders said they had occasional problems with condensation. Most of them thought that this problem could be alleviated if occupants opened their windows. Montreal builders responded to the ventilation problem by installing exhaust fans. However, one Montreal builder stated that he found the exhaust system to be noisy.

There were no problems reported with heat pumps or high efficiency furnaces. Both of these items are normally installed by the builders' heating subcontractors who are responsible for maintenance as well.

The only builder in the survey who installed heat exchangers had problems with a manufacturer's defect. He was quick to point out, however, that the supplier replaced the defective heat exchangers and was very prompt in dealing with the problem.

In conclusion, although builders did not see it as a serious problem, condensation,associated with airtightness and low airchange rates,was perceived as a potential problem.

3. Willingness to Install Energy Saving Measures

Builders said that they often included energy saving measures on options lists but if they did not sell they took them off. Builders do not leave unpopular options on the list, as they must be prepared to offer them by having a supplier available and, if needed, they must use specialized trades. This factor is important for heat pumps, heat exchangers and improved efficiency furnaces. Builders can be more flexible about offering variations of the measures which they already install, (e.g., insulation, windows, thermostats and vapour barriers).

The consumer survey showed that relatively few builders had energy saving measures on their options list (see Exhibit E-15, earlier). Given builders' general willingness to put energy saving measures on options lists, it appears that lack of consumer interest explains this situation.

One might have expected the custom and/or small builders to be the innovators or "early adopters" in the energy conservation field because:

- their clientele have their own plans for a house and a subset of their clientele would likely have plans specially oriented to the installation of energy saving measures

- flexibility in tailoring a house to the consumer's demands is the small builder's selling feature.

Generally speaking, the survey showed that small and custom builders as well as large builders are fairly innovative.

4. Energy Saving Measures as a Marketing Strategy

Builders generally did not perceive the offering of energy saving measures as part of a marketing strategy. The exception was one builder in Ottawa, who used energy saving as part of a marketing strategy to sell "quality" homes.

Two builders, in Calgary and Vancouver respectively, had tried to use the actual installation of energy saving measures as marketing tools but found this not to be a success. In Calgary, they added extra

insulation, furnaces and special caulking. There was no consumer interest in these houses and the builder felt the reason was simply the higher price ($4,000 more). The builder noted that gas is not a big expense in Calgary and consequently there was no economic incentive to buy these houses. In Vancouver, builders who provided passive solar layouts said that people were interested enough to look at the houses but they did not show preference for them over less costly houses.

5. Availability of Information About Energy Saving Meausres

Builders thought that there was enough information about energy saving measures from the suppliers of new materials and equipment. Several of them mentioned CMHC and HUDAC seminars. None of the builders expressed the view that they did not receive enough information, with one exception: that builder said that he could not find information about a reliable heat exchanger and did not know of suppliers.

CONCLUSIONS OF THE BUILDER SURVEY

The builder survey led to the conclusion that there were no strong impediments to the installation of energy saving measures on the part of the suppliers of housing. Builders are very responsive to the demands of customers and do not show a reluctance to try something new. However, most builders do not appear to take the initiative to suggest special energy saving measures to their customers unless asked.

SUMMARY OF BUILDER INTERVIEWS

CITY: HALIFAX

FEATURES INSTALLED / BUILDER CHARACTERISTICS	INSULATION LEVEL* W	C	B	AIR TIGHTNESS CAULKING	NO CAULKING	HEAT PUMP	IMPROVED EFFICIENCY FURNACE	EXHAUST WITH HEAT EXCH	WITHOUT HEAT EXCH	PASSIVE SOLAR
LARGE BUILDER	R22	R30-40	To floor	std.		1	None	None	None	None
MEDIUM BUILDER	R20	R30	Code		std.	None	None	None	None	None
SMALL BUILDER	R20	R30-40	To floor	std.		None	None	None	None	None
CUSTOM BUILDER	R20	R30-40	To floor	std.		2	2-3	None	None	None

W = exterior wall
C = ceiling
B = basement
std. = standard
on req. = on request

* For metric values divide by 5.67

SUMMARY OF BUILDER INTERVIEWS

CITY: MONTREAL

BUILDER CHARACTERISTICS / FEATURES INSTALLED	INSULATION LEVEL** W	C	B	AIR TIGHTNESS CAULKING	NO CAULKING	HEAT PUMP	IMPROVED EFFICIENCY FURNACE	EXHAUST WITH HEAT EXCH	WITHOUT HEAT EXCH	PASSIVE SOLAR
LARGE BUILDER	R12	R34	To floor		std.	None	N/A***	None	std.	None
MEDIUM BUILDER	R16	R31	To floor	std.		1	N/A	None	None	None
SMALL BUILDER	R12	R31	Code		std.	2% of houses	N/A	None	std.	None
CUSTOM BUILDER*	R20	R34	Code	std.		15% of houses	N/A	None	None	None

W = exterior wall
C = ceiling
B = basement
std. = standard
on req. = on request

* Another custom builder was interviewed but does not appear here.

** For metric values divide by 5.67

*** N/A = not applicable

SUMMARY OF BUILDER INTERVIEWS

CITY: OTTAWA

BUILDER CHARACTERISTICS \ FEATURES INSTALLED	INSULATION LEVEL* W	INSULATION LEVEL* C	INSULATION LEVEL* B	AIR TIGHTNESS CAULKING	AIR TIGHTNESS NO CAULKING	HEAT PUMP	IMPROVED EFFICIENCY FURNACE	EXHAUST WITH HEAT EXCH	EXHAUST WITHOUT HEAT EXCH	PASSIVE SOLAR
LARGE BUILDER	R20	R32	2 ft.	std.		3	1	None	None	None
MEDIUM BUILDER	R33	R40	½ way	std.		5	None	None	None	None
SMALL BUILDER										
CUSTOM BUILDER	R26 or R32-33	R40 or R48	2 ft to floor	std.		on req.	on req.	15	None	std.

W = exterior wall
C = ceiling
B = basement
std. = standard
on req. = on request

* For metric values divide by 5.67

SUMMARY OF BUILDER INTERVIEWS

CITY: TORONTO

FEATURES INSTALLED / BUILDER CHARACTERISTICS	INSULATION LEVEL* W	C	B	AIR TIGHTNESS CAULKING	NO CAULKING	HEAT PUMP	IMPROVED EFFICIENCY FURNACE	EXHAUST WITH HEAT EXCH	WITHOUT HEAT EXCH	PASSIVE SOLAR
LARGE BUILDER [1]	R19	R40	Code	std.		5-10	std. [2]	None	None	None
MEDIUM BUILDER	R17	R20-30	Code		std.	None	on req.	None	None	None
SMALL BUILDER										
CUSTOM BUILDER	R20	R40 1/3 of houses	Code		std.	std. [3]	std. [4]	None	None	None

W = exterior wall
C = ceiling
B = basement
std. = standard
on req. = on request

1 Insulation levels stated for $120,000-$170,000 houses. Cheaper houses have insulation according to the code.

2 In houses costing $90,000-$150,000

3 Only in latest subdivision

4 Installing 1 super efficient furnace also

* For metric values divide by 5.67

SUMMARY OF BUILDER INTERVIEWS

CITY: CALGARY

BUILDER CHARACTERISTICS / FEATURES INSTALLED	INSULATION LEVEL* W	C	B	AIR TIGHTNESS: CAULKING	AIR TIGHTNESS: NO CAULKING	HEAT PUMP	IMPROVED EFFICIENCY FURNACE	EXHAUST: WITH HEAT EXCH	EXHAUST: WITHOUT HEAT EXCH	PASSIVE SOLAR
LARGE BUILDER	R15	R40	Code	std.		None	std.	None	None	None
MEDIUM BUILDER	R17	R34	To floor		std.	None	None	None	None	None
SMALL BUILDER	R14	std.	To floor		std.	None	None	None	None	None
CUSTOM BUILDER										

W = exterior wall

C = ceiling

B = basement

std. = standard

on req. = on request

* For metric values divide by 5.67

SUMMARY OF BUILDER INTERVIEWS

CITY: VANCOUVER

FEATURES INSTALLED / BUILDER CHARACTERISTICS	INSULATION LEVEL * W	C	B	AIR TIGHTNESS CAULKING	NO CAULKING	HEAT PUMP	IMPROVED EFFICIENCY FURNACE	EXHAUST WITH HEAT EXCH	WITHOUT HEAT EXCH	PASSIVE SOLAR
LARGE BUILDER	R20	R28	Code	std.		None	None	None	None	None
MEDIUM BUILDER	R12	R28	Code		std.	None	None	None	None	None
SMALL BUILDER	R12	R20	Code		std.	None	1	None	None	None
CUSTOM BUILDER	Code	Code	Code		std.	None	None	None	None	None

W = exterior wall
C = ceiling
B = basement
std. = standard
on req. = on request

* For metric values divide by 5.67

APPENDIX F

EVALUATION OF NON-ECONOMIC FACTORS

APPENDIX F

EVALUATION OF NON-ECONOMIC FACTORS

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APPENDIX F

EVALUATION OF NON-ECONOMIC FACTORS

INTRODUCTION

The accompanying factor-measure matrix (Exhibit F-1) gives the reader an overview of the following:

1. The factors that have an impact on the adoption of each measure
2. The number of factors that have an impact on each measure
3. The degree to which each factor has an impact on a measure
4. Whether the impact of a factor on a measure is positive or negative

A scale has been chosen from minus 2 to plus 2 to rank the impacts of a factor on a measure. A blank square should be interpreted as zero impact.

The remainder of this section comments on the rationale behind each number in the matrix.

A. SUPPLY FACTORS

Factor Number

1. Potential Lack of Builder or Product Designer Know-How

Houses are generally tighter than they were a decade ago. Increased air tightness, however, has usually not been accompanied by exhaust systems. Therefore a minus 2 appears for "Airtightness plus Exhaust" and "Airtightness plus Heat Exchanger". Many builders reported that they perceived minor condensation problems, which they felt could be alleviated by the occupants' opening the windows. They also stated

Exhibit F-1

THE FACTOR/MEASURE MATRIX

-1, -2 } FACTOR HAS NEGATIVE IMPACT ON PENETRATION OF MEASURE

+1, +2 } FACTOR HAS POSITIVE IMPACT ON PENETRATION OF MEASURE

FACTORS \ MEASURES	INSULATION	IMPROVED FURNACE (GAS)	CONDENSING GAS FURNACE	IMPROVED FURNACE (OIL)	SUPER EFFICIENT FURNACE (OIL)	HEAT PUMP, ELECTRIC OR GAS BACKUP	AIRTIGHT., NO EXHAUST	AIRTIGHT., + EXHAUST	AIRTIGHT., + HEAT EXCHANGER	NIGHT SETBACK THERMOSTAT	PASSIVE SOLAR
LACK OF BUILDER & DESIGNER KNOW-HOW						-1		-2	-2		
PRODUCT'S REPUTATION WITH BUILDERS									-2		
INEXPERIENCE OF TRADES						-1	-1	-1	-1		
LAGS IN SUPPLY OF HOMES											
USED OR NOT AS SALE TOOL	+1	+1	-1		-1	-1	-1	-1	-1		
PERCEIVED HEALTH HAZARDS	-1		-1		-1		-2				
DAMAGE TO STRUCTURE & CONTENTS							-1				-1
COMFORT							+1			+1	
SUMMER EFFECTS	+1					+2					-1
AESTHETICS						-1					-1
SOCIAL IMAGE						+1					+1
REPUTATION WITH CONSUMERS						-1					
PROPERTY TAXES						-1					
BUILDING CODES											
INFORMATION TO PUBLIC	+2		-1		-1	-2	-2	-2		+1	+1
FUTURE ENERGY PRICES	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
PRICING BY UTILITIES						-1			+1		
UTILITY/REGULTORY POLICY	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

that the habits of the occupants can cause increased condensation problems. Such factors as the number of people living in the house, or the number of showers that they take, or whether the house is closed up all day will have an impact on the condensation problems that a "tight" house can experience when it has no exhaust system. It can be concluded that the level of knowledge and understanding regarding air quality standards, required air changes is lacking, not only at the designer/builder level but also at the fundamental research level.

A minus 1 appears under heat pumps because builders may be reluctant to install heat pumps if their regular heating subcontractor is not familiar with them. Smaller builders who have installed heat pumps themselves, have not had problems with them, however.

2. Reputation of the Product or its Suppliers with the Builders

A minus 2 is shown under air-to-air heat exchangers as two builders reported dissatisfaction with these devices. One builder had installed 14 of these devices each one of which had a manufacturer's defect and had to be replaced. Another builder said that he did not know of any good manufacturer of air-to-air heat exchangers, and consequently did not install them. Other builders showed little interest in this device.

3. Potential Inexperience of the Trades

A negative impact is shown in the "Airtightness" columns. How airtight a house will be, depends almost exclusively on the care with which the materials are applied. Therefore, the skill of the trades is crucial for the effectiveness of airtightness measures.

There are installation problems with heat pumps as well. According to a government publication*, heat pumps can be rendered ineffective by improper installation.

4. Lags in Supply of Homes With Energy Saving Measures

Builders appear to be very responsive to the consumers' desires. In today's competitive market the builder must tailor his product to the consumer. Consequently, this factor is not considered to inhibit the take-up of any energy-saving measures. Although not every house in a subdivision can have equally effective passive solar features because of layout problems, the demand for passive solar layouts does not seem to outstrip the supply of these homes and therefore there is no "lag of supply" involved. All other measures can be installed at short notice when a customer buys a house not yet built, which is the most common form of buying homes today.

5. Builders' Marketing Methods and the Use of Energy Saving as a Selling Tool

There are both positive and negative impacts here. A plus 1 is shown under insulation, as a basic level is in the building code, and further levels appear on the options list of some builders. A minus 1 is shown under airtightness, condensing gas furnaces, highly efficient oil furnaces, and air-to-air heat exchangers. None of these items appear often on option lists today. A blank is shown

* Ontario Ministry of Energy, "Builders Guide to Energy Efficiency in New Housing, p.83.

under the nighttime setback thermostat, as this item is easily retrofitted and is less dependent on active marketing by builders than other measures. It is frequently a standard feature in new homes.

B. PERFORMANCE FACTORS

6. Perceived Health Hazards

The health factor has the greatest negative impact (-2) on the installation of airtightness without exhaust systems. High levels of airtightness without exhaust systems have resulted in reports of nausea, dizziness and are often perceived as potential sources of ill health.

The health factor also has an impact of minus 1 on the installation of condensing gas furnaces and air-to-air heat exchangers. Condensing gas furnaces do not need a chimney. The public sometimes perceives having no chimney as a hazard and several survey respondents thought that it caused health problems.

A minus 1 appears under insulation because some people were thinking of the reported health problems associated with urea formaldahyde foam; 38% of the respondents mentioned this problem.

7. Potential Damage to Structure and Contents

Structural damage can arise potentially in the case of airtightness without an appropriate air exhaust system. This is due to condensation that occurs at cold spots within the envelope. With lack of ventilation in the attic, there may be frost build-up in the attic. Consequently, a minus 1 appears under airtightness without exhaust.

A minus 1 appears under passive solar layout as fading of furniture and rugs can occur.

8. Interior Comfort

A plus 1 is shown under airtightness without exhaust, and under the nighttime set-back thermostat. Individuals like airtightness because uncomfortable drafts can be eliminated. As the majority of respondents preferred the temperature cooler at night, the nighttime set-back thermostat adds to comfort in most instances.

9. Summer Effects

This factor will have a positive influence on the installation of both types of heat pumps because they are also air conditioners. Consequently a plus 2 appears under heat pumps. A minus 1 appears under passive solar layout as many people think that without an air conditioning system a house with passive solar layout would be too hot in the summer. As insulation helps to keep some heat out, a plus one appears under insulation. There is a blank under airtightness plus exhaust. This measure has no impact on the installation as the home owner can still open the windows.

10. Aesthetics

A minus 1 appears under passive solar layout. Passive solar layouts require changes in house design and some people do not like them. A minus 1 appears under heat pumps as they can sometimes spoil the appearance of the house if the lot layout does not permit their installation in an inconspicuous place.

11. Social Image

Heat pumps have a very good social image as they offer the opportunity to exhibit energy saving measures conspicuously. Consequently, a plus 1 is shown under heat pumps. The same reasoning led to showing plus 1 under passive solar layouts.

12. Reputation of Product With the Consumer

A minus 2 is shown under heat pumps. Several respondents expressed concern over the cost, maintenance and technological capability of heat pumps. Many thought they were not fully developed as yet.

C. INSTITUTIONAL FACTORS

13. Property Taxes

A minus 1 is shown under heat pumps, as the installation of a heat pump with its air conditioning feature may cause the house to be reassessed at a higher rate than otherwise. Several respondents thought that would be the case and there was a newspaper report of this occurring in Ontario.

14. Building Codes and Standards

Builders prefer to use 2 x 6's to install extra insulation because they can get extra R-value without using cladding (which is awkward to install). Although one might theorize that builders would prefer to use 2 x 6's when extra insulation was installed, actually no problems were identified as being created by the building code in the choice of 2 x 4's or 2 x 6's. No other problems were identified that were due to building codes.

15. Availability of Information to the Public

There is a plus 2 under insulation, a plus 1 under passive solar layout and a plus 1 under nighttime set-back thermostat as the public seems generally well informed about these features. When individuals think of conserving heat, they most often think of insulation rather than airtightness. Regarding airtightness, there is insufficient information on air quality standards not only at the public level but also at the expert level as noted elsewhere. For that reason, a minus 2 is shown under airtightness with and without exhaust.

A minus 2 appears under heat pumps as the public is not fully aware of the efficiency of the heat pump and there is some perception that heat pumps may need substantial maintenance.

The air-to-air heat exchanger is virtually unknown. Consequently, a minus 2 appears here as well. A minus 1 appears under the condensing gas furnace and the high efficiency oil furnace. Although there is knowledge and widespread use of improved efficiency furnaces, there is very little information about the new and more advanced types of furnaces.

16. Expectations Regarding Future Energy Prices

Most survey respondents expected energy prices to rise with inflation or a little faster. As this has a positive impact on all energy saving measures, a plus 1 appears across the Table.

17. Incentive or Disincentive Pricing by Utilities

A minus 1 appears under the heat pump since the true cost of incremental electricity is higher than the rates charged and, therefore, there is less incentive to the electrical consumer to save energy in the present system than in a system that has less discrepency between incremental utility costs and revenues.

A plus 1 appears under air-to-air heat exchangers, since relatively low electricity dates make this device cheaper to operate.

18. Utility/Regulatory Policies to Minimize Rates and Increase Sales

Utilities and the regulatory bodies endeavour to minimize energy rates, partly achieved through increased sales; this leads to a negative impact on the installation of energy saving measures by virtue of relatively little effort by utilities to promote those specific measures that save the greatest amounts of energy.* Therefore a minus 1 appears under all the measures.

---

* Note that utilities do use the issue of energy saving, however, when persuading consumers to switch from one energy form to the other.

APPENDIX G

CONSUMER QUESTIONNAIRE

ENERGY SAVING
FEATURES IN NEW HOUSES

CONSUMER QUESTIONNAIRE

FOR OFFICE USE ONLY

CODING/EDITING:

Halifax 1
Montreal 2
Ottawa 3
Toronto 4
Calgary 5
Vancouver 6

RESPONDENT I.D. # _____

RESPONDENT INFORMATION:

NAME: MR. (__)
MRS. (__) _____
MISS (__)
MS. (__)

ADDRESS: _____

_____

APT. #: _____

CITY: _____

PROVINCE: _____

TEL #: ( ) - _____

INTERVIEW RECORD

INTERVIEW COMPLETED ON:

DATE: _____ TIME: Started _____ Ended _____

CALLBACK INFORMATION (IF NECESSARY)

DATE: _____ TIME: _____ (__) a.m. (__) p.m.

DATE: _____ TIME: _____ (__) a.m. (__) p.m.

DATE: _____ TIME: _____ (__) a.m. (__) p.m.

DATE: _____ TIME: _____ (__) a.m. (__) p.m.

RESPONDENT: WANTS RESULTS ( )
DOES NOT WANT RESULTS ( )

.....2

Instructions for Interviewer:

Read to the consumer whatever appears in BLOCK CAPS in the following pages. Your instructions will be in regular type.

HELLO, MY NAME IS _____ FROM PEAT, MARWICK AND PARTNERS. IS THIS MR./MRS._____?

If a child is on the telephone, ask for one of the parents. If parents are not at home, ask when they will be in. Call again at that time (maximum 3 times). If they are not home after calling 4 times in total, strike the name from the list.

If it is an adult,

WE ARE CONDUCTING A SURVEY FOR CANADA MORTGAGE AND HOUSING CORPORATION ON ENERGY-SAVING FEATURES IN NEW HOMES.

HAVE YOU PURCHASED A NEWLY BUILT HOUSE IN THE PAST 12-18 MONTHS?

If answer "yes"
If answer "no"

OUR SURVEY IS LIMITED TO THOSE WHO HAVE PURCHASED NEW HOUSES OVER THE PAST 12 MONTHS. THANK YOU VERY MUCH FOR YOUR TIME. GOOD BYE.

WE WOULD APPRECIATE IF YOU COULD ANSWER A FEW QUESTIONS TO HELP THE GOVERNMENT GET AN UNDERSTANDING OF CONSUMER'S VIEWS ON ENERGY CONSERVATION. YOUR ANSWERS WILL BE CONFIDENTIAL, OF COURSE, AND WE WILL MAKE THE RESULTS OF THE SURVEY AVAILABLE TO YOU IF YOU WISH. WOULD YOU BE WILLING TO ANSWER A FEW QUESTIONS?

If answer "yes"
If answer "no"

THANK YOU VERY MUCH FOR YOUR TIME. GOOD BYE.

WHO DO YOU THINK WE SHOULD TALK TO ABOUT ENERGY SAVING FEATURES DESIGNED FOR THE HOME? YOURSELF OR SOMEONE ELSE?

If answer "someone else" → skip to page 3.
If answer "themselves"

THE INTERVIEW WILL TAKE ABOUT 15 MINUTES. IS THIS A CONVENIENT TIME FOR YOU OR WOULD IT BE BETTER TO CALL YOU AT ANOTHER TIME? (Arrange the time if necessary)(Skip to Qu. 1).

.....3

COULD I SPEAK TO _____?
If not home - Ask when will he/she be back and call back.

If home - THE INTERVIEW WILL TAKE ABOUT 15 MINUTES. IS THIS A CONVENIENT TIME FOR YOU OR WOULD IT BE BETTER TO CALL YOU AT ANOTHER TIME? (Arrange the time if necessary).

1. ARE YOU A FIRST-TIME HOME BUYER?

Yes _____0
No _____1

2. HOW MANY YEARS DO YOU PLAN TO STAY IN YOUR HOUSE?

Years _____

3. WHAT TYPE OF HOUSE DID YOU BUY? (Read list)

	Check (✓)
BUNGALOW	_____1
2-STOREY DETACHED	_____2
SEMI-DETACHED	_____3
ROW HOUSE	_____4
DUPLEX	_____5
OTHER	_____6

4. WAS THE HOUSE ...

	Check (✓)
- CUSTOM BUILT?	_____1
- BUILT AFTER YOU SAW A MODEL HOME?	_____2
- BUILT AFTER YOU SAW PLANS?	_____3
- ALREADY BUILT WHEN YOU BOUGHT IT?	_____4

5. WHAT IS THE PRIMARY METHOD OF HEATING YOUR HOME. BY PRIMARY I MEAN THE ONE METHOD YOU RELY ON MOST? (Do Not Read List)

(Record one answer only)

	Check (✓)
Natural Gas	_____1
Electricity	_____2
Oil	_____3
Other	_____4

.....4

6. NOW WE WOULD LIKE TO ASK YOU A FEW QUESTIONS ABOUT ENERGY SAVING FEATURES IN NEW HOUSES.

LET ME FIRST ASK YOU ABOUT <u>FURNACES</u>.

DO YOU HAVE A HIGH-EFFICIENCY FURNACE IN YOUR NEW HOUSE?

Yes _____ 0
Skip to Qu. 8 ← No _____ 1
Don't Know _____ 2 → Skip to Qu. 12

7. HOW MUCH DID IT COST?

Skip to Qu. 11 ← $_____

▶ 8. WAS IT OFFERED BY THE BUILDER AS AN OPTION?

Skip to Qu. 10B ← Yes _____ 0
No _____ 1

9. IF IT HAD BEEN OFFERED WOULD YOU HAVE BOUGHT IT?

Skip to Qu. 11 ← Yes _____ 0
No _____ 1

10A. WHY NOT?

▶ 10B. WHAT WAS THE REASON YOU DID NOT HAVE IT INSTALLED? (Do Not Read List)

		Check (✓)
	1. Doesn't pay	_____ 1
	2. Doesn't work	_____ 2
	3. Did not think of it	_____ 3
Skip to Qu. 13 ←	4. Did not know enough about it	_____ 4
	5. Has disadvantages	_____ 5
	6. Couldn't afford it	_____ 6
	7. Installing it ourselves	_____ 7

▶ 11. DO YOU BELIEVE THERE IS A GREATER RISK OF GAS FUMES FROM A HIGH-EFFICIENCY GAS FURNACE?

Yes ____ 0 No opinion ____ 2
No ____ 1

.....5

▶12. WOULD YOU MIND NOT HAVING A CHIMNEY ON YOUR HOUSE?

Yes _____ 0 No Opinion _____ 2
No _____ 1

13. ARE YOU AWARE OF ANY OTHER PROBLEMS WITH HIGH-EFFICIENCY FURNACES?

Yes (specify) _____ 0 No opinion _____ 2
_____

No _____ 1

14. LET ME NOW ASK YOU ABOUT INSULATION.

DID YOU HAVE EXTRA INSULATION ADDED TO THE BASIC LEVEL OFFERED BY THE BUILDER?

Yes _____ 0
Skip to Qu. 16 ← No _____ 1
Don't Know _____ 2 → Skip to Qu. 20

15. HOW MUCH EXTRA DID IT COST?

Skip to Qu. 19 ← $_____

▶16. WAS EXTRA INSULATION OFFERED BY THE BUILDER AS AN OPTION?

Skip to Qu. 18B ← Yes _____ 0
No _____ 1

17. IF IT HAD BEEN OFFERED WOULD YOU HAVE BOUGHT IT?

Skip to Qu. 19 ← Yes _____ 0
No _____ 1

18A. WHY NOT?

▶ 18B. WHAT WAS THE REASON YOU DID NOT HAVE IT INSTALLED? (Do Not Read List)

		Check (✓)
	1. Doesn't pay	____1
	2. Doesn't work	____2
	3. Did not think of it	____3
Skip to Qu. 20 ←	4. Did not know enough about it	____4
	5. Has disadvantages	____5
	6. Couldn't afford it	____6
	7. Installing it ourselves	____7

▶ 19. CAN YOU REMEMBER WHAT THE BASIC LEVEL IS?

Yes ____0 (specify) _____
No ____1

▶ 20. DO YOU THINK THERE ARE ANY IMPACTS ON YOUR PROPERTY TAXES BECAUSE OF EXTRA INSULATION?

Yes ____0 No opinion _____2
No ____1

21. DO YOU BELIEVE THAT THERE IS A GREATER RISK OF FIRE ASSOCIATED WITH MORE INSULATION?

Yes ____0 No opinion _____2
No ____1

22. ARE YOU AWARE OF ANY OTHER PROBLEMS WITH INSULATION?

Yes (specify) _____ 0
No _____1
No opinion _____2

23. LET ME NOW ASK YOU ABOUT THERMOSTATS.

DID YOU HAVE A TIME-CONTROLLED THERMOSTAT INSTALLED?

Yes ____0
Skip to Qu. 25 ← No ____1
Don't Know ____2 → Skip to Qu. 29

24. HOW MUCH DID IT COST?

Skip to Qu. 29 ← $_____

▶ 25. WAS IT OFFERED BY THE BUILDER?

Skip to Qu. 27B ← Yes _____ 0
No _____ 1

26. IF IT HAD BEEN OFFERED WOULD YOU HAVE BOUGHT IT?

Skip to Qu. 29 ← Yes _____ 0
No _____ 1

27A. WHY NOT?

▶ 27B. WHAT WAS THE REASON YOU DID NOT HAVE IT INSTALLED? (Do Not Read List)

Skip to Qu. 29 ←

		Check (✓)
1.	Doesn't pay	_____ 1
2.	Doesn't work	_____ 2
3.	Did not think of it	_____ 3
4.	Did not know enough about it	_____ 4
5.	Has disadvantages	_____ 5
6.	Couldn't afford it	_____ 6
7.	Installing it ourselves	_____ 7

28.

▶ 29. WOULD YOU MIND THE HOUSE BEING A LITTLE COOLER WHEN SLEEPING?

I do mind _____ 0
I don't mind _____ 1
I prefer it cooler _____ 3
No opinion _____ 2

30. DO YOU LOWER THE THERMOSTAT SETTING YOURSELF NOW?

Check (✓)

Never	____1
Sometimes	____2
Always	____3

31. AT WHAT TEMPERATURE DO YOU USUALLY KEEP YOUR THERMOSTAT? ____ Degrees

32. NOW A FEW QUESTIONS ABOUT HEAT PUMPS.
DO YOU HAVE A HEAT PUMP IN YOUR HOUSE?

	Yes ____0	
Skip to Qu. 34 ←	No ____1	
	Don't Know ____2 →	Skip to Qu. 39

33. HOW MUCH DID IT COST?

Skip to Qu. 37 ← $_____

▶ 34. WAS IT OFFERED BY THE BUILDER?

Skip to Qu. 36B ←	Yes ____0
	No ____1

35. IF IT HAD BEEN OFFERED WOULD YOU HAVE BOUGHT IT?

Skip to Qu. 37 ←	Yes ____0
	No ____1

36A. WHY NOT?

▶ 36B. WHAT WAS THE REASON YOU DID NOT HAVE IT INSTALLED?
(Do Not Read List)

		Check (✓)
	1. Doesn't pay	____1
	2. Doesn't work	____2
	3. Did not think of it	____3
Skip to Qu. 39 ←	4. Did not know enough about it	____4
	5. Has disadvantages	____5
	6. Couldn't afford it	____6

▶ 37. DO YOU THINK THAT THE INSTALLATION OF A HEAT PUMP WOULD INCREASE YOUR PROPERTY TAXES?

Yes ____ 0 No opinion ____ 2
No ____ 1

38. ARE YOU AWARE OF ANY PROBLEMS WITH HEAT PUMPS?

Yes (specify) _____ 0
No ____ 1
No opinion ____ 2

▶ 39. NOW ABOUT AIR-TIGHTNESS.

DO YOU HAVE SPECIAL AIR-TIGHTNESS EITHER WITH OR WITHOUT CONTROLLED EXHAUST?

Yes ____ 0 with exhaust ( ) without exhaust ( )
Skip to Qu. 42 ← No ____ 1
Don't Know ____ 2 → Skip to Qu. 47

40. HOW MUCH EXTRA DID IT COST? $_____

41. DO YOU HAVE A HEAT EXCHANGER?

Skip to Qu. 45 ← Yes ____ 0
No ____ 1

▶ 42. WAS IT OFFERED BY THE BUILDER?

Skip to Qu. 44B ← Yes ____ 0
No ____ 1

43. IF IT HAD BEEN OFFERED WOULD YOU HAVE BOUGHT IT?

Skip to Qu. 45 ← Yes ____ 0
No ____ 1

44A. WHY NOT?

▶ 44B. WHAT WAS THE REASON YOU DID NOT HAVE IT INSTALLED? (Do Not Read List)

		Check (✓)
	1. Doesn't pay	____ 1
	2. Doesn't work	____ 2
	3. Did not think of it	____ 3
Skip to Qu. 46 ←	4. Did not know enough about it	____ 4
	5. Has disadvantages	____ 5
	6. Couldn't afford it	____ 6

▶ 45. DO YOU THINK THAT SPECIAL AIR-TIGHTNESS WITH AN EXHAUST SYSTEM CAUSES ANY HEALTH PROBLEMS?

Yes ____ 0
No ____ 1

AND WITHOUT AN EXHAUST SYSTEM?

Yes ____ 0
No ____ 1

▶ 46. ARE YOU AWARE OF ANY OTHER PROBLEMS WITH SPECIAL AIR-TIGHTNESS AND CONTROLLED EXHAUST?

Yes (specify) _____ 0

No ____ 1
No opinion ____ 2

▶ 47. NOW ABOUT SOLAR FEATURES.

DOES YOUR HOUSE HAVE PASSIVE SOLAR CONSTRUCTION FEATURES? BY THAT I MEAN, LARGE WINDOWS FACING SOUTH.

Yes ____ 0
Skip to Qu. 49 ← No ____ 1

48. HOW MUCH EXTRA DID IT COST?

Skip to Qu. 52 ← $_____

▶ 49. WAS IT OFFERED BY THE BUILDER AS AN OPTION?

Skip to Qu. 51B ← Yes _____ 0
No _____ 1

50. IF IT HAD BEEN OFFERED WOULD YOU HAVE BOUGHT IT?

Skip to Qu. 52 ← Yes _____ 0
No _____ 1

51A. WHY NOT?

▶ 51B. WHAT WAS THE REASON YOU DID NOT BUY A HOUSE WITH PASSIVE SOLAR FEATURES? (Do Not Read List)

		Check (✓)
	1. Doesn't pay	_____ 1
	2. Doesn't work	_____ 2
	3. Did not think of it	_____ 3
Skip to Qu. 54 ←	4. Did not know enough about it	_____ 4
	5. Has disadvantages	_____ 5
	6. Couldn't afford it	_____ 6
	7. Did not like appearance of house	_____ 7

▶ 52. DO YOU THINK PASSIVE SOLAR FEATURES MAKE THE HOUSE TOO HOT IN THE SUMMER?

Yes ____ 0 No opinion ____ 2
No ____ 1

53. DO YOU THINK THAT A HOUSE WITH PASSIVE SOLAR FEATURES HAS ANY OTHER DISADVANTAGES?

Yes (specify) _____ 0
_____
_____

No ____ 1
No opinion ____ 2

▶ 54. I AM GOING TO READ THE LIST OF ENERGY SAVING FEATURES THAT WE HAVE TALKED ABOUT. AS I GO DOWN THE LIST I WOULD LIKE YOU TO GIVE ME YOUR JUDGEMENT AS TO WHETHER OR NOT THE FEATURE WOULD INCREASE THE RESALE VALUE OF YOUR HOME. I WOULD LIKE YOU TO USE THE FOLLOWING CATEGORIES.

1. INCREASE THE VALUE BY MORE THAN WHAT YOU PUT IN
2. LESS THAN WHAT YOU PUT IN
3. NOT AT ALL
4. NO OPINION.

(Read List)	More Than It Cost	Less Than It Cost	None	Don't Know
1. HEAT PUMP	____ 1	____ 2	____ 3	____ 4
2. PASSIVE SOLAR	____ 1	____ 2	____ 3	____ 4
3. EXTRA INSULATION	____ 1	____ 2	____ 3	____ 4
4. SUPER-EFFICIENT FURNACE	____ 1	____ 2	____ 3	____ 4
5. SUPER AIR-TIGHTNESS WITHOUT A HEAT EXCHANGER	____ 1	____ 2	____ 3	____ 4
6. HEAT EXCHANGER	____ 1	____ 2	____ 3	____ 4

55. NOW, LET ME ASK YOU ABOUT SOME OTHER FEATURES. WHICH OF THE FOLLOWING FEATURES DO YOU HAVE IN YOUR NEW HOME? (Read list)

	Check (✓)
1. WASHER, DRYER	____ 1
2. DISHWASHER	____ 1
3. FREEZER	____ 1
4. DELUXE KITCHEN CABINETS	____ 1
5. EXTRA-QUALITY BROADLOOM	____ 1
6. FIREPLACE - IN LIVING ROOM	____ 1
- IN FAMILY ROOM OR BASEMENT	____ 1
- IN BOTH	____ 1
7. HUMIDIFIER	____ 1
8. FRENCH DOORS	____ 1
9. FINISHED BASEMENT	____ 1
10. TWO-CAR GARAGE	____ 1
11. CENTRAL AIR CONDITIONING	____ 1
12. WET BAR	____ 1
13. MORE THAN TWO BATHROOMS	____ 1
14. LANDSCAPING	____ 1
15. SAUNA	____ 1
16. AIR CLEANER	____ 1
17. CENTRAL VACUUM	____ 1
18. INTERCOM SYSTEM	____ 1
19. SECURITY SYSTEM	____ 1
20. HEATILATOR	____

56. DID YOU MAKE "AN EITHER/OR" CHOICE BETWEEN ANY ONE OF THE ABOVE FEATURES WHICH YOU HAVE, AND AN ENERGY SAVING FEATURE?

Yes (specify) _____ 0
_____
_____

No _____ 1
No opinion _____ 2

57. NOW, A FEW QUESTIONS ABOUT FINANCES.

WHEN YOU DECIDED THAT YOU COULD AFFORD A HOUSE, DID YOU MAKE AN ESTIMATE OF THE FOLLOWING: (Read list)

	Check (✓)
MORTGAGE PAYMENTS	_____ 1
PROPERTY TAXES	_____ 1
ENERGY COSTS	_____ 1
REPAIRS AND MAINTENANCE	_____ 1
EXPECTED INCREASE IN THE VALUE OF YOUR HOUSE	_____ 1
OTHER COSTS (Record)	_____ 1

58. DID YOU ACTUALLY MAKE CALCULATIONS ON PAPER?

Skip to Qu. 60 ← Yes _____ 0
No _____ 1

59. WHEN YOU BOUGHT THE HOUSE, DID YOU KNOW HOW MUCH YOU WOULD PAY ANNUALLY FOR HEATING OR ELECTRICITY?:

Heating _____ 0
Electricity _____ 1

Skip to Qu. 62

▶ 60. HOW MANY FUTURE YEARS DID YOU INCLUDE IN YOUR CALCULATIONS?

Years _____

61. DID YOU USE THE SERVICES OF A FINANCIAL ADVISOR? (E.G., BANK OR TRUST COMPANY OFFICIAL)?

Yes _____ 0
No _____ 1

* In Halifax, insert oil instead of natural gas.

▶ 62. DO YOU THINK THAT IN THE NEXT FIVE YEARS THE PRICE OF NATURAL GAS* WILL: (Read list)

RISE MUCH MORE THAN INFLATION	____1
RISE A LITTLE MORE THAN INFLATION	____2
STAY THE SAME AS INFLATION	____3

63. DO YOU BELIEVE THAT A SHORTAGE WILL OCCUR IN THE SUPPLY OF NATURAL GAS* IN THE NEXT TWENTY YEARS: (Read list)

IS PROBABLE	____1
IS NOT LIKELY	____2
DON'T KNOW	____3

64. HAVE YOU EVER READ ANY PUBLICATION (e.g., Magazines) ABOUT ENERGY SAVING FEATURES IN HOMES?

Yes	____0
No	____1

Skip to Qu. 66

65. WAS THERE ANY REASON WHY NOT? (Do not read list)

Not interested	____1
Were you unable to find it?	____2
Other	____3

Skip to Qu. 68

▶ 66. HOW DID YOU OBTAIN YOUR COPY? (Do not read list)

		Check (✓)
1.	Picked it up.	____1
2.	Sent in a coupon from an ad.	____2
3.	Called/wrote in for a copy.	____3
4.	Friend/Colleauge/neighbour gave me one.	____4
5.	Home Owners Association supplied one.	____5
6.	Contractor/Builder supplied one.	____6
7.	Fuel/hydro/power supply company supplied one.	____7
8.	Just came in the mail.	____8
9.	Other (specify).	____9
10.	Cannot remember/don't know.	____00

67. FROM THE PUBLICATION (Read list):

DID YOU LEARN A LOT? ____ 1
A LITTLE? ____ 2
NOTHING? ____ 3

▶ 68. DO YOU KNOW OF ANY FRIENDS WHO HAVE INSTALLED ANY OF THE ENERGY SAVING FEATURES THAT WE TALKED ABOUT?

Yes ____ 0
Skip to Qu. 71 No ____ 1

69. HAVE THEY SUGGESTED THAT YOU SHOULD DO THE SAME?

Yes ____ 0
Skip to Qu. 71 No ____ 1

70. DID YOU INSTALL ANYTHING ON THEIR RECOMMENDATION?

Yes (record) ____ 0
No ____ 1

▶ 71. NOW A FEW LAST QUESTIONS ABOUT YOURSELF, IF YOU DON'T MIND. IN WHICH OF THE FOLLOWING AGE CATEGORIES DO YOU BELONG? (Read list)

20-30 1
31-40 2
40-50 3
over 50 4

72. WHAT IS YOUR OCCUPATION? (Record)

73. WHAT IS YOUR COMBINED HOUSEHOLD INCOME? (Read List)

UNDER $20,000? 1
$20,000-$35,000? 2
$35,000-$50,000? 3
OVER $50,000? 4

74. HOW MANY PEOPLE LIVE IN YOUR HOUSE?

Number: _____

75. IN WHICH OF THE FOLLOWING PRICE RANGES DOES YOUR HOUSE BELONG? (Read list)

$45,000 - 60,000	1
60,000 - 80,000	2
80,000 - 100,000	3
100,000 - 150,000	4
150,000 - 250,000	5
Over 250,000	6

Sex: M ___ 1, F ___ 2 (Don't ask)